Essays in market microstructure of NYSE-listed IPOs

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Essays in Market Microstructure of NYSE-Listed IPOs

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Abstract

In essay 1, we investigate the effect of decimalization on the aftermarket trading of NYSE-listed IPOs. We find that after decimalization, the relation between spreads and underpricing becomes negative, suggesting that benefits from the increased price competition accrue more to hot IPOs. The depths are generally smaller post-decimalization because of the higher probability of front-running that aggravates the costs of adverse selection and limit order submission. In addition, we show that underwriters still provide price support but are only willing to cover the initial short position if it is still profitable post-decimalization. We also find that decimal pricing does not change the flipping strategy of institutions for cold IPOs as flipping is likely bound by underwriter price support and shares allocation. Institutions, however, tend to flip more hot IPOs in the post- rather than pre-decimalization period, suggesting that the cost of flipping is much lower for those share prices with a substantial run-up during aftermarket trading.

Essay 2 investigates the effect of decimalization on quote revision (both depth and spread) behavior of NYSE-listed IPO stocks. We find that specialists revise their quoted depth more frequently than quoted spread in both the pre- and post-decimalization periods. The proportion of spread revisions among cold and warm IPOs, however, increases after decimalization, suggesting that decimalization helps to reduce the binding constraint on spreads of cold and warm IPOs. But there is no change in the proportion of spread revisions in hot IPOs. In the post-decimalization period, the proportion of bid depth increases is higher, which implies that specialists tend to improve their bids with a smaller increment in depth, compared to the pre-decimalization period. We also show that specialists are more likely to revise quotes that result in a change in spread for high-priced, high-volatility and/or less reputable underwriters IPOs, and to revise quotes that result in a change in depth for IPOs with smaller underpricing and/or higher risk.

In essay 3, we examine the effects of decimalization on returns, volatility, and limit order executions of the NYSE-listed IPOs. We find that the opening price captures almost all the initial return in pre- and post-decimalization periods. However, the initial and intraday returns of hot IPOs are smaller in post-decimalization period. The results reveal that there is no profit opportunity for day-traders who buy and sell shares of newly listed issues during the first trading day, and the higher front-running probability explains the lower returns of hot IPOs in post-decimalization period. The volatility is higher at the start of trading, suggesting the information-driven trade is greater during this period, and it stabilizes throughout the rest of the day. The intraday volatility is significantly lower for hot and warm IPOs, especially at the start of trading, throughout the day in post-decimalization period, suggesting that the information flows changed after decimalization. The proportion of limit order executions is lower after decimalization due to the lower displayed liquidity and the lower cost of submitting market orders. The proportion of limit order executions at the start of trading is higher in pre- and post-decimalization, and stabilizes quickly. In post-decimalization, the proportions of limit order executions for hot and warm IPOs are lower at the start of trading, but cold IPOs do not exhibit the same. These results suggest that the execution rate of limit orders depends on underpricing.

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Essay 1

Decimalization, IPO Aftermath, and Liquidity

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Abstract

This essay investigates the effect of decimalization on the aftermarket trading of NYSE-listed IPOs. We find that after decimalization, the relation between spreads and underpricing becomes negative, suggesting that benefits from the increased price competition accrue more to hot IPOs. The depths are generally smaller post-decimalization because of the higher probability of front-running that aggravates the costs of adverse selection and limit order submission. In addition, we show that underwriters still provide price support but are only willing to cover the initial short position if it is still profitable post-decimalization. We also find that decimal pricing does not change the flipping strategy of institutions for cold IPOs as flipping is likely bound by underwriter price support and shares allocation. Institutions, however, tend to flip more hot IPOs in the post- rather than pre-decimalization period, suggesting that the cost of flipping is much lower for those share prices with a substantial run-up during aftermarket trading.

Keywords: Decimalization; IPO; Underpricing; Liquidity; Aftermath
JEL Classification: G18; G24; G12; G10; G19

Decimalization, IPO Aftermath, and Liquidity

I. Introduction

Since decimalization was fully implemented by all U.S. stock markets in 2001,[1] numerous studies have analyzed the impact of decimalization on various aspects of market quality. For example, Charkravarty, Harris, and Wood (2001a, 2001b) show that the decimal pricing resulted in narrower quoted and effective spreads, and in thinner quoted depths at best bid and ask prices on the New York Stock Exchange (NYSE). Similarly, Bacidore et al. (2001), and NYSE (2001a, 2001b) show that NYSE stocks exhibit smaller spreads and depths after decimalization. Chakravarty, Wood and Van Ness (2004) also show similar results by finding that both the number of trades and trading volume declined significantly on the NYSE after decimalization.

While earlier studies add to the understanding of the effects of decimalization on various aspects of market quality, they focus mainly on the well-established seasoned stocks. An initial public offering (IPO) is an important activity and event in the capital markets, as it is the only way for a company to be listed publicly and to access the capital markets. The number of IPOs each year is often used as an indication of the health of an economy and the IPO underwriting business is an important source of revenue for investment banks and financial institutions. Uncertainty and information asymmetric are especially high for newly listed firms as they do not have prior trading history (e.g., Corwin, Harris and Lipson (2004)). However, no study has yet explored how

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[1] NYSE and AMEX implemented decimal pricing initially with a small numbers of stocks on August 28, September 25, and December 4, 2000, and finally with the remaining stocks on January 29, 2001. However, for NASDAQ, it experimented the decimal pricing in March 2001 and went to full implementation in April 9, 2001.

decimalization may affect the aftermarket liquidity and trading activity of newly listed firms.

The secondary market liquidity, especially on the first day of trading, is crucial for a successful IPO. A liquid market not only helps reduce the market stabilization costs administered by underwriters and the market making costs faced by market makers, but also ensures the issuing firms access to capital markets in future with lower cost of capital.[2] Ellis, Michaely, and O'Hara (2000) find that the lead underwriter is the only active liquidity provider for the IPO on Nasdaq, especially when a newly listed security has been traded below the offer price. Using a proprietary database, Corwin, Harris, and Lipson (2004) provide evidence that limit orders are an important and informative source of liquidity for IPOs listed on NYSE. They show that the underwriter always provides stabilization for IPOs with greater selling pressures by submitting orders on the trading floor. Boehmer and Fishe (2004) find that the lead underwriter provides substantial liquidity to the market when share price falls below the offer price, share price volatility increases, or when market liquidity decreases.

In this study, we provide the first investigation of the impact of decimalization on trading on the listing day of IPOs on NYSE.[3] Chart A of Figure 1 shows that the average volume per trade and the average number of trades of the NYSE-listed IPOs are tremendously high on the first IPO trading day, and stabilizes rapidly after the second day onwards in both pre- and post-decimalization periods. In Chart B, we also observe that

[2] Amihud and Mendelson (1986) and Brennan and Subrahmanyam (1996) provide a detailed discussion on the relation between liquidity and stock returns. Butler, Grullon, and Weston (2002) find that investment banks charge lower fees to seasoned equity offering firms with more liquid stocks.

[3] The start of IPOs aftermarket trading is unique, important, and is a period of extremely high trading activity (e.g., Corwin, Harris, and Lipson (2004), Ellis, Michaely, and O'Hara (2000, 2002), and Ellis (2006)). Price stabilization and flipping are important activities, especially during the IPOs first day of trading.

the average quoted depth per quote and the number of quotes are relatively higher on the first day. This unique IPO trading characteristic makes our analyses particularly important for understanding the relations between decimalization and liquidity, underwriter supports, and flipping activity. Our findings also have important implications for decimalization on aftermarket trading of IPOs and provide a complete picture of decimalization on newly listed securities in addition to seasoned stocks.

[Insert Figure 1 here]

We examine only NYSE-listed IPOs for the following reasons. First, the IPO listing requirements and market microstructures of NYSE and Nasdaq are different.[4] Second, Nasdaq has higher industry clustering of technology firms,[5] and experienced the bursting of the internet bubble during our sample period.[6] The use of Nasdaq stocks may therefore contaminate the analysis. Third, Chung, Van Ness, and Van Ness (2003) note that the trade and quote (TAQ) database reports only the largest, not the aggregate, depth at the inside market for Nasdaq issues, but the aggregate depth, specialist depth plus all the limit orders at the quoted price, for NYSE issues. Hence, it would not be possible to study the depths on Nasdaq with TAQ data.

Using the TAQ data from the NYSE, we analyze the spreads and depths for a sample of 114 and 116 NYSE-listed IPOs before and after decimalization during 1998-

[4] Corwin and Harris (2001) find that smaller and riskier firms tend to list on Nasdaq to avoid the higher listing fees on the NYSE. For market microstructure, NYSE is an order-driven market where a call auction allows supply and demand to be aggregated prior to the start of trading. However, Nasdaq is a quote-driven market. Dealers can only specify their best quotes, and participants have no idea of supply and demand away from the inside quotes. Thus, the aggregating demand feature of the NYSE's structure suggests that IPOs listed there will have less underpricing and narrower spreads than IPOs that trade on Nasdaq (see Falconieri et al. (2003)). Importantly, the underwriter typically becomes the market maker of Nasdaq-listed IPOs, but NYSE Rule 98 requires an organizational separation between the underwriter and the specialist.
[5] Using Standard and Poors Global Industry Classification Standard (GICS) industry code at the 10-industry sector level, about 28% of the firms are classified in information technology industry on Nasdaq, whereas only 7% of the firms are information technology on NYSE.
[6] Ritter and Welch (2002) document that the percentage of technology IPOs dropped from 72 percent (803 IPOs) during internet bubble in 1999 – 2000 to 29 percent (80 IPOs) in 2001.

2004. We stratify our sample into hot, warm and cold IPOs based on their offer-to-open returns.[7] We define hot, warm, and cold IPOs as those whose opening prices are more than 10 percent above the offer price, 10 percent or less of the offer price, and at or below the offer price, respectively.[8] We find that the spreads of IPOs on the listing day are generally smaller in post-decimalization period, but the reduction is larger and significant for hot and warm IPOs. These results suggest that the price competition of hot and warm IPOs increases in the post-decimalization period. Consistent with previous research on seasoned stocks, the depths of IPOs narrowed after decimalization. Both bid and ask depths decrease significantly for hot and cold IPOs. The adverse selection cost of submitting limit orders and the cost between market and limit orders after decimalization explain this smaller display of liquidity for IPOs. The intraday comparison for depths and spreads in pre- and post-decimalization periods show that the ask depth is greatly smaller throughout the day, the bid depth does not decrease immediately, at least at the start of trading, and the spreads are also smaller throughout the day. The high frequency of trades, volumes, and limit buy order executions at offer price, and that of below the offer price suggest that the underwriter still supports the cold IPOs at offer price, and covers the initial short position below offer price from market purchases when it is still profitable in the post-decimalization period.

[7] To control for market conditions, we also compute the market-adjusted offer-to-open return using the market return (NYSE value-weighted return) prior to the IPO listing day. We find that the Pearson and Spearman's correlations between the offer-to-open return and market-adjusted offer-to-open return are higher at 99% and above in both pre- and post-decimalization. Corwin, Harris, and Lipson (2004) find that there is no relationship between hot IPO markets and liquidity.

[8] We plot the distribution of the offer-to-open returns in pre- and post-decimalization periods, and find that the cutoff point of the offer-to-open returns is at 10%. Previous studies normally use ad-hoc cutoff points to classify hot, warm, and cold IPOs. Schultz and Zaman (1994) and Ellis, Michaely, and O'Hara (2000) classify the IPOs that traded above the offer price as hot IPOs, and IPOs that traded at and below their offer price as cold IPOs. Corwin, Harris, and Lipson (2004) classify hot IPOs as those that open more than 15% above the offer price, and cold IPOs as those that open at or below the offer price. Aggarwal and Conroy (2000) split their IPOs based on offer-to-open returns into weak IPOs with offer-to-open return less than or equal to 10%, and hot IPOs with offer-to-open return greater than 20%.

In addition, decimal pricing does not change the flipping strategy of institutions for cold IPOs, as flipping is bound by underwriter price stabilization and regular share allocation to institutions. Institutions, however, flip more hot IPOs in post-decimalization than in the pre-decimalization period, indicating that the cost of flipping is much lower for those stocks whose share prices increase substantially and rapidly in aftermarket trading.

The rest of the essay is organized as follows. Section 2 discusses the literature reviews on decimalization and aftermarket trading of IPOs. Section 3 describes the sample data and research methodology. Section 4 presents our empirical results concerning the effects of decimalization on liquidity and aftermarket trading of IPOs. Section 5 summarizes and concludes.

II. Literature Review

Decimalization and liquidity

A series of changes were made to the minimum price variation on the New York Stock Exchange (NYSE). On June 24, 1997, the tick size was reduced from \$1/8 to \$1/16. With the aim of aligning the NYSE with international practices, decreasing transaction costs, and making prices more easily understood by all investors, the NYSE initiated a decimalization program to further reduce the tick size to \$1/100 or one cent. Additionally, prices are now quoted in decimals instead of fractions. The conversion was carried out over four stages, with the first stage occurring on August 28, 2000 and the last stage was completed on January 29, 2001. Henceforth, numerous studies were conducted to investigate the effects of these tick size reductions on the spreads and depths of NYSE stocks (see, for example, Bollen and Whaley (1998), Goldstein and Kavajecz (2000), Van Ness, Van Ness, and Pruitt (2000), Chung and Chuwonganant (2002), Bacidore, Battalio, and Jennings (2003), and Chakravarty, Wood, and Van Ness (2004)).

Bollen and Whaley (1998), Goldstein and Kavajecz (2000), and Van Ness, Van Ness, and Pruitt (2000) investigate the effects of the tick size reduction from $1/8 to $1/16 on common stocks. They find that the overall spread and depth decreased after the tick size change. Chung and Chuwonganant (2002) analyze the effects of the tick size change on quote revisions. They discover that the number of quote revisions that involve the changing of the spread increased significantly after the tick size change. Furthermore, they find that the number of quote revisions initiated by changes in the spread is smaller for stocks with lower prices and/or larger volumes. They interpret the result as evidence that the $1/16 tick size is still a binding constraint on absolute spreads. The authors provide evidence that decimalization further reduces price rigidity and increases price competition by showing a significant increase in the frequency of spread and price quote revisions after decimalization.

Chakravarty, Harris, and Wood (2001a, 2001b) analyze the effects of decimalization on the NYSE pilot stocks and find that decimal pricing lead to lower quoted and effective spreads. They show that the depths at the best bid and ask prices are much smaller after decimalization. Empirical studies by the NYSE (2001a, 2001b) document the changes that occurred after the NYSE converted to decimal pricing. Firstly, transaction costs fell. The effective spreads, on average, fell by 43%, the average bid-ask spread fell by more than half compared to the pre-decimalization size, and net price improvement rose 29%. Secondly, the number of trades increased by 76%, and the number of limit orders doubled. However, transaction size fell. The average limit order size fell by 21%, and 42.4% of the limit orders were cancelled compared to 34.2% during the pre-decimalization period. Thirdly, decimalization had adversely affected the transparency of the market. The quoted amount of interest fell by an average of two-thirds. Lastly, the NYSE reported that more than 80% of trades occurred at spreads larger than one cent, showing that sub-decimal pricing would not bring about much gain to the market. Although the displayed liquidity is lower and cancellation is higher following decimalization, Bacidore, Battalio, and Jennings (2003) find that the lower displayed liquidity does not result in poor execution quality as traders do not reduce the use of limit orders in favor of market orders. Using a matched sample of decimal and non-decimal stocks on the NYSE, Chakravary, Wood, and Van Ness (2004) find that the quoted depth, quoted and effective spreads, number of trades, and trading volume declined significantly after decimalization, and conclude that the effect of decimalization on market liquidity is mixed.

Chung, Charoenwong, and Ding (2004) document that the reduction in spread and depth caused by decimalization is, firstly, due to the removal of the binding constraint imposed by the tick size. After decimalization, the constraint on spread imposed by the tick size is greatly reduced, as the minimum spread required is only $0.01. Secondly, the increase in the probability of front running (i.e., the usage of insider information to act in advance of upcoming transactions) also contributes to the decrease in spread and depth. As decimalization has effectively reduced the cost of stepping in front of existing orders to $0.01, professional traders are more likely to engage in front running, resulting in narrower spreads. Due to this higher probability of front running, traders are reluctant to display their interest. As a result, quoted depth is reduced. The authors also report that decimalization leads to changes in five stock attributes (i.e., share price, number of trades, trade size, return volatility, and market capitalization), which in turn affects the spread and depth. In addition, they observe that sub-penny pricing may further reduce the spreads of high volume, low risk, or low price stocks.

However, the effects of decimalization may vary across the hot and cold IPOs due to the following reasons:

(1) The price competition of hot IPOs increases as the costs of stepping ahead (buy and sell sides) are much lower after decimalization. However, the price competition is limited in the case of cold IPOs because (i) the underwriter is the major liquidity provider, and provides certain price support at the IPO offering price for the cold IPOs to maintain their reputation. (ii) investors, who were allocated the initial shares, may want to quote a smaller ask price to get rid of this cold issue immediately, but they may feel indifferent to quoting only one cent above the bid price or to submit a market order at the bid price after decimalization. Thus, the spreads of the cold IPOs will not reduce much after decimalization if investors submit limit sell orders.

(2) Aggarwal and Conroy (2000) document that the price discovery process of IPOs is almost completed just before the opening of the secondary market trading. Therefore, the large sell information content in cold IPOs is richer than hot IPOs (Schultz and Zaman (1994) and Krishnan, Singh, and Zebedee (2003)), and the information asymmetric of the cold IPOs is also lower than the hot IPOs. It is obvious that the quoted spreads are lower for the cold IPOs as compared to the hot IPOs. Since the large sell information and the information asymmetric component of the cold IPOs is still the same after decimalization, we do no expect that the spreads of cold IPOs to decrease significantly in the post-decimalization period.

Therefore, we hypothesize that decimalization reduces the spreads more for more-underpriced IPOs (hot IPOs) than less-underpiced IPOs (cold IPOs).

$$S_{post}^{Hot} - S_{pre}^{Hot} < S_{post}^{Cold} - S_{pre}^{Cold}$$

In summary, previous studies only provide evidence of the effect of decimalization on the market liquidity of seasoned stocks. However, given the importance of secondary market liquidity for IPOs, we provide the first investigation of the effect of decimal pricing on the IPO stocks.

Since the degrees of underwriter price support and flipping activity for IPOs are dependent on the underpricing, the decimalization may have different levels of impact on its liquidity in the aftermarket trading. However, how the decimal pricing may affect the aftermarket liquidity of IPO is not clear enough without further examining the price stabilization of underwriter and flipping activity in the aftermarket trading.

Decimalization and underwriter price support

The research on aftermarket trading in IPOs of underwriters and other market participants has grown in recent years. One of the important aftermarket activities is whether an underwriter offers price stabilization to an IPO in the aftermarket trading. Benveniste, Busaba, and Wilhelm (1996) argue that price support is a bonding mechanism to alleviate the worry of investors from receiving the higher offer price issues. Chowdhry and Nanda (1996) show that stabilization by an underwriter helps to relieve the winner's curse for uninformed investors. Lewellen (2003) argues that price support also helps to maintain the underwriter's reputation with the investor. Ruud (1993) shows that the distribution of initial returns is nearly censored at zero, which suggests that the underwriter stabilizes IPOs at the offer price. Hanley, Kumar, and Seguin (1993) find evidence that the lead underwriter engages in stabilization and temporarily inflates the stock price for overpriced offerings. Schultz and Zaman (1994) find that underwriters generally quote the highest bids and actively support the price of less successful IPOs, and argue that this price support has a permanent impact on increasing aftermarket price. Ellis, Michaely, and O'Hara (2000) use a unique database to examine the aftermarket trading of lead and co-lead underwriters on Nasdaq-listed IPOs, where lead the underwriter is a market maker. They find that the lead underwriter accumulates a large inventory in aftermarket trading and engages in stabilization activity for less successful IPOs. Aggarwal (2000) documents that underwriters purchase 16% of the offering in the aftermarket to cover their short position as a form of price support. Boehmer and Fishe (2002, 2004) find that underwriter actively repurchases shares in offerings that trade below the offer price to provide stabilization. Corwin, Harris, and Lipson (2004) use proprietary data from a NYSE System Order to show that NYSE-listed IPOs have unusually high limit order book depth on the first day of trading, and fall to a stable level within two to three weeks. Bid-ask spreads of limit order books are unusually low at the start of trading. Furthermore, hot IPOs have a significant buy imbalance during the first half hour of trading, whereas cold IPOs have a significant sell imbalance throughout the first day of trading. The authors find that the underwriter provides price stabilization to the cold IPOs through the trading floor, which contributes an average 74% of quoted bid depth on the first trading day.

Price support for IPOs is not only important and necessary, but also profitable in aftermarket trading. To provide aftermarket stabilization for an IPO, the underwriter typically oversells the issue to hold a short position when trading starts (see, for example, Ritter (1998), Aggarwal (2000), Ellis, Michaely, and O'Hara (2000), Fishe (2002), and Boehmer and Fishe (2004)). If the share price declines below the offer price, the underwriter may use market purchase to cover their short position and earn a profit from covering below the offer price. However, if the share price goes up substantially in aftermarket trading of an IPO, underwriters may exercise the over-allotment option[9] to cover the short position and earn the gross spread from exercised shares. Therefore, both short-covering and over-allotment offers a great incentive for the underwriter to provide price support in the aftermarket trading to eliminate the cost of stabilization to the underwriter. However, how decimal pricing may affect the trading strategy of the underwriter is explored in this study.

Boehmer and Fishe (2004) find that the underwriter benefits from short-covering in the aftermarket trading if the share price declines sufficiently below the offer price, and argue that the short-covering is more valuable than over-allotment options for an underwriter in the cold issues. Krishnan, Singh, and Zebedee (2003) document that there is no hard floor at the offer price in the secondary market support for cold IPOs, which is consistent with the underwriter's short-covering below offer price. In the post-decimalization period, since the minimum tick size is only $0.01, the cost of short-covering may increase if the share price does not drop substantially below the offer price. It is possible that an underwriter may provide the price support by short-covering only when it is still profitable (many ticks below the offer price), although the tick size is only one cent. Therefore, the underwriter's price stabilization from short-covering for cold IPOs should be similar in both the pre- and post-decimalization period.

[9] Over-allotment option is also known as Green Shoe option. Normally, the issuer allows the underwriter to offer shares up to 115% with an over-allotment options agreement, and to exercise the options within 30-days after an IPO. In our sample, 226 out of 230 NYSE-listed IPOs have the over-allotment options agreement with underwriters.

We hypothesize that the underwriter's price stabilization from short-covering for cold IPOs should be similar in both the pre- and post-decimalization period.

Decimalization and flipping activity

The activity of selling shares immediately after trading starts is known as flipping. Flipping of IPO shares is active in aftermarket trading and is related to the degree of underpricing. Krigman, Shaw, and Womack (1999) use seller-initiated block trades (10,000 shares or more) to proxy for the extent of flipping, and find that institutions (1) flip IPOs more than individuals do and (2) flip more cold IPOs. The flipping by institutions account for 45% of total dollar volume on the first day for cold IPOs and 22% for hot IPOs. Aggarwal (2003), using a unique proprietary data set, find that institutions are allocated more than 73% of the IPO shares, and conclude that institutions do more flipping than retail investors, but hot IPOs are flipped more than cold IPOs by institutions. The author also documents that flipping accounts for 23% of trading volume for cold IPOs and 17.5% for hot IPOs. Fishe (2002) presents a model to show that stock flippers have greatest effect on pricing in weak IPOs and provide an explanation for underwriter price support. However, it is still unknown how the decimal pricing may affect the flipping activity in aftermarket trading of IPOs.

Since the tick size in the post-decimalization period is only \$0.01, given the price uncertainty and asymmetric information at the start of aftermarket trading for IPOs, the adverse selection cost faced by the limit order traders is even higher in the post-decimalization period, as the probability of front-running is now higher. This implies that the cost of submitting the market orders is lower than that of submitting the limit orders.

Further, institutions tend to consume liquidity rather than to provide liquidity. Therefore, the cost of flipping is relatively lower for stock flippers in the post-decimalization period. On the other hand, due to the lower displayed liquidity in the post-decimalization period, stock flippers may also face a higher cost of flipping, as they may have to consume more depth at different quotes.

As previous studies document that the degree of flipping varies across IPOs, the smaller tick size may have different impacts on the stock flipper's[10] strategy on different IPO issues, i.e., hot, warm, cold IPOs. In the pre- and post-decimalization period, the underwriter is the only liquidity provider for the cold IPOs, and still allocates, preferably to institutions, a large proportion of IPO shares (more than 73%). Given the common underwriter price support and regular shares allocation to institutions, it is possible that the benefit and cost of flipping for cold IPOs in the post-decimalization period are bound in the aftermarket trading. Although institutions find it less costly to flip after decimalization, the flipping activities of cold IPOs is restricted by underwriter price support and their shares allocation. Therefore, if the stock flippers tend to flip cold IPOs in the pre-decimalization period, it is impossible that the decimal pricing could alter their flipping strategy. However, if the share prices increase substantially and rapidly, i.e., hot IPOs, after the opening trading, the stock flippers may find it less costly to flip the shares at such high prices by front-running the orders by just one cent in the post-decimalization period. For these high demand issues, the low cost of flipping may provide incentive and advantage to the stock flippers, especially institutions, in the post-decimalization period.

[10] Krigman, Shaw, and Womack (1999) and Aggarwal (2003) document that the institutional investors flip more than retail investors in aftermarket trading. Also, institutional investors tend to consume liquidity rather than provide liquidity.

Therefore, we hypothesize that decimalization induces higher institutional flipping for hot IPOs than cold IPOs.

III. Data and Research Methodology

The IPO sample

The IPO data are obtained from the Securities Data Corporation (SDC) New Issue database during 1998–2004. We exclude unit offerings, closed-end funds, ADRs, and REITs from our sample. These data selection criteria yield a sample size of 230 NYSE-listed IPOs. We use SDC database to obtain the basic information on offer date, offer price, number of shares issued, net proceeds, underwriter compensation, number of lead and co-lead managers, underwriter market shares, and over-allotment shares. We also extract the financial information, such as total assets, net sales, total debt, total liabilities, earnings before interests and taxes (EBIT), returns on assets (ROA), and returns on operating cash flows (Cash ROA), from Compustat database. All the financial data are based on the most recent fiscal year ending prior to the IPO. If the data are missing in Compustat, we supplement it from their IPO prospectus filed with the SEC. The market value defined as first day closing price times the post-IPO share outstanding is obtained from the Center for Research in Securities Prices (CRSP) database. For each IPO, we retrieve the transaction data from the NYSE's TAQ database. The transaction data provide the time, price, and volume for each trade and quote. As Blume and Goldstein (1997) show, quotes that originate from off the NYSE only occasionally better NYSE quotes. Hence, only NYSE quotes are used in this study.

For the TAQ database, we omit the following to minimize data errors: (1) quotes if either the ask price or bid price is less than or equal to zero; (2) quotes if either the ask size or the bid size is less than or equal to zero; (3) quotes if the bid price is greater than or equal to the ask price; (4) quotes if the bid-ask spread is greater than $5; (5) before-the-open and after-the-close trades and quotes; (6) trades if the price or volume is less than or equal to zero; (7) out-of-sequence trades and quotes.

Table 1 presents the distribution of the 230 NYSE-listed IPOs. Using January 29, 2001, the full scale implementation of decimal pricing, as the cutoff date, 114 and 116 IPOs are grouped into before and after decimalization samples. Each sub-group of IPOs is further divided into three sub-samples categorized by their initial returns defined as offer-to-open returns. Based on our earlier definition of hot, warm and cold IPOs, there are 52 hot, 33 warm, and 29 cold IPOs issued before decimalization and 48 hot, 40 warm, and 28 cold IPOs issued after decimalization.[11] This sub-grouping is necessary since the degree of market stabilization by underwriters and flipping activity are likely to vary across IPOs.

[Insert Table 1 here]

Since we compare IPOs in the pre- and post-decimalization period, the similarity of the IPOs in pre and post period is very important in this study. Table 1 shows that the industry[12] distribution of IPOs is comparable in the pre- and post-decimalization sample. The offer and firm characteristics of IPOs are presented in Table 2. Generally, there is no significant difference between the pre- and post-decimalization samples in terms of issue and firm characteristics.

[11] Consistent with the argument of underwriter price stabilization in cold IPOs, 25 out of the 29 and 22 out of the 28 cold IPOs open at exactly the offer price in the pre- and post-decimalization period, respectively.
[12] IPOs are assigned a Standard and Poors Global Industry Classification Standard (GICS) industry code at the 10-industry sector level.

In Panel A of Table 2, the means of shares offered, net proceeds, offer price, over-allotment shares, gross spread, and underwriter market shares are not significantly different before and after decimalization. The means (medians) of offer price are \$18.73 (\$17.00) and \$19.16 (\$18.00) in pre- and post decimalization, respectively. Both the mean and median of gross spread before and after decimalization are 7–8%, which is consistent with findings reported in Chen and Ritter (2000). The mean and median open-to-close returns are 0.52% and 0.00%, respectively, in pre-decimalization. The mean and median open-to-close returns in post-decimalization are 1.00% and 0.34%, respectively. Both the mean and median of open-to-close are not statistically significant in pre- and post-decimalization. This result is consistent with Barry and Jennings (1992), Schultz and Zaman (1994), and Aggarwal and Conroy (2000) who report that the opening price captures almost all the initial returns. The small open-to-close return in pre- and post-decimalization suggests that our classification for hot, warm, and cold IPOs using offer-to-open returns is indifferent to offer-to-close returns. The mean and median show that the over-allotment shares account 10% to 14% of the number of shares offered in pre- and post-decimalization, which is consistent with the Green Shoe option agreement.

We present the firm characteristics in Panel B of Table 2. The market capitalization, total assets and net sales, which are used as proxies for the firm size of IPOs, are on average similar before and after decimalization. The total debt, total liabilities, and debt to asset ratio are insignificantly different between pre- and post-decimalization. The profitability measures, EBIT, ROA, and Cash ROA, are also not significantly different before and after decimalization. Collectively, these results suggest that our analysis of pre- and post-decimalization will not be affected by the IPO issue and firm characteristics in the pre- and post-decimalization period.

[Insert Table 2 here]

Spreads and depths

We employ four traditional spread measures of market liquidity in this study: (1) Quoted spread in dollars $[(A_{i,t} - B_{i,t})]$; (2) Quoted spread as a proportion of quote midpoint $[(A_{i,t} - B_{i,t})/M_{i,t}]$; (3) Effective spread in dollars $[2 \cdot D_{i,t} \cdot (P_{i,t} - M_{i,t})]$; and (4) Effective spread as a proportion of quote midpoint $[2 \cdot D_{i,t} \cdot (P_{i,t} - M_{i,t})/ M_{i,t}]$, where, $A_{i,t}$ is the quoted ask price for stock i at time t, $B_{i,t}$ is the quoted bid price for stock i at time t, $M_{i,t}$ is the midpoint of $A_{i,t}$ and $B_{i,t}$, $P_{i,t}$ is the transaction price for stock i at time t, and $D_{i,t}$ is trade direction which is equal to +1 for buyer-initiated trades and -1 for seller-initiated trades. The Lee and Ready (1991) algorithm[13] is used to classify trades into buys and sells. Following Bessembinder (2003), we make no allowance for trade reporting lags to access whether trades are buyer or seller initiated.

As Lee, Mucklow, and Ready (1993) note, any study of liquidity provision must examine changes in both prices and depth. Prior studies found that the quoted depth of NYSE stocks declines significantly after the tick size changes (e.g. Goldstein and Kavajecz (2000), Bacidore et al. (2001), Chakravarty, Harris, and Wood (2001a, 2001b), and Chakravarty, Wood, and Van Ness (2004)). However, the changes in tick size may not equally affect the bid and ask depths of the hot, warm, and cold IPOs due to the different degrees of front-running and underwriter supports. We, therefore, decompose

[13] Assigning trades completed at prices above (below) the prevailing quote midpoint as customer buys (sells). Trades executed at the quote midpoint are assigned by the "tick test", in which trades at a higher (lower) price as compared to the most recent trade at a different price are classified as buys (sells).

the depth into bid and ask depths in terms of share and dollar depths for hot, warm, and cold IPOs in this study.

For each IPO, we first compute the time-weighted quoted spread, the trade-weighted effective spread, and time-weighted quoted depth (total, bid, and ask depth) and depth imbalance in pre- and post-decimalization on the first day of IPO aftermarket trading. We then compute the cross-sectional means and medians of these variables. The t-test and Wilcoxon signed rank test are employed to examine the pre- and post-decimalization differences in mean and median values, respectively.

IV. Empirical Results

Spreads

We observe in Table 3 that both the quoted and effective spreads in dollars for hot IPOs are generally higher than warm and cold IPOs.[14] This finding is consistent with Hanley, Kumar, and Seguin (1993) who document that the spreads narrow when market price is close to the offer price and stabilization is most likely, and Krishnan, Singh, and Zebedee (2003) who argue that the information content of large sells during the stabilization period is the lowest in the quoted spread of cold IPOs. Schultz and Zaman (1994), Hegde and Miller (1989), and Miller and Reilly (1987) also find that spreads are narrower for stocks that are likely to be supported.

Consistent with the findings for seasoned stocks in previous studies, the quoted and effective spreads, measured in dollars and proportion, for all IPOs are significantly

[14] The Wilcoxon signed ranks tests (not reported) show that the medians of both quoted dollar spread and effective dollar spread for hot IPOs are higher than cold IPOs, and statistically significant at 1% in pre-decimalization. However, the medians are not significantly different between hot and cold IPOs in post-decimalization. This result supports our findings later that hot IPOs receive greater spread reductions after decimalization.

smaller in the post-decimalization period. However, the means and medians of quoted and effective spreads are significantly smaller only for hot and warm IPOs at the 1% level in post-decimalization sample. Both quoted and effective dollar spreads decline by an average of 36% to 58% and 31% to 53% for hot and warm IPOs, respectively. For cold IPOs, the dollar spreads decrease by less than 51%; the t-test is not significant for the mean difference of effective spreads. The proportion spreads of hot and warm IPOs also decline more than cold IPOs. These results suggest that the price competition of hot IPOs increases due to the lower cost of front-running in the post-decimalization period. The high probability of front-running in post-decimalization comes mainly from two sources – sell-side front-running and buy-side stepping-ahead. Since the demand for hot IPOs is high, the traders may feel it less costly to compete with the market and limit buy orders in post-decimalization. On the other hand, the stock flippers may flip more hot IPOs with lower trading costs as the share prices of hot IPOs usually increase substantially and quickly after the opening trade. For cold IPOs, the spreads do not reduce as much as hot IPOs because it is possible that the underwriter still provides a certain degree of price support at the offer price (see Ruud (1993), and Hanley, Kumar, and Seguin (1993)) in the post-decimalization period, which bounds the bid price equal to the offer price. Therefore, the reduction of spreads is mainly attributed to the stepping-ahead from the sell-side traders.

[Insert Table 3 here]

Depths

The share and dollar depth are smaller and significant for all IPOs in the post-decimalization period (see Table 3). These smaller depths are more prominent for hot and cold IPOs, which are about 1/3 of the depths in the pre-decimalization period. This low displayed liquidity is consistent with the higher adverse selection cost faced by limit orders traders, and the lower cost of submitting market orders in the post-decimalization period. Further, for all IPOs, the ask depth reduces by an average of 60% and is statistically significant at the 1% level. However, the bid depth reduces by 43%. The ask depths of hot and cold IPOs decrease by 72% and 59%, respectively. The bid depths of cold IPOs are higher than hot IPOs in pre- and post-decimalization, supporting the evidence of the underwriter price support for cold IPOs. Generally, the decimalization has a greater impact on ask depth than bid depth, which is most likely attributable to the trading behavior of IPOs. In aftermarket trading, underwriters tend to provide liquidity or price support for the IPOs, especially cold IPOs, and the demand for hot IPOs is usually high. Therefore, the reduction in bid depth is generally smaller than ask depth after decimalization.

The depth imbalance, defined as the difference between bid and ask depth stated as a percentage of bid plus ask depth, decreases for all IPO categories, but the decrease is not statistically significant. The number of quotes is also higher and significant for hot, warm, and cold IPOs. In summary, the depths of IPOs, regardless of the extent of underpricing, decline due to the decimal pricing as the decimal pricing aggravates the high adverse selection cost and high probability of front-running at the initial stage of IPO trading.

Trading Activities

We present the first day trading activities of IPOs in pre- and post-decimalization periods in Table 4. The mean and median differences of average trading volume and average trading value between pre- and post-decimalization periods are not statistically significant for all IPO categories. However, the average trading volume at ask for all IPOs (last column of Table 4) increase significantly in the post-decimalization period, but the average trading volume at bid is not significant. The higher trading volume at ask in the post-decimalization period is not surprising as the cost of stepping-ahead from the buy side, and of submitting market orders, is relatively lower in the post-decimalization period. The average trading volumes at ask for warm and cold IPOs also increase after decimalization. However, the average trading volume at bid is not significantly different for all IPO categories in post-decimalization compared to the pre-decimalization period.

The proportion of trading volume at bid (ask) also show a monotonic decreasing (increasing) to the IPO underpricing, suggesting that the selling pressure is higher for cold IPOs. Consistent with the argument that the cost of flipping in hot IPOs is lower after decimalization, the proportion of trading volume at bid is significantly higher for hot IPOs in the post-decimalization period. Table 4 also shows that the number of trade at ask and bid prices decrease significantly for hot, warm, and cold IPOs in the post-decimalization period. Interestingly, we observe that the number of trades inside the spread increases significantly after decimalization, suggesting that the traders have no incentive to reveal their interests in the trades given a smaller tick size in post-decimalization.

The number of trades in terms of median increase on the first day trading of IPOs in the post-decimalization period increases statistically significantly for hot, warm, and cold IPOs. We compute the average return volatility based on the intraday returns on the first trading day of each IPO. The return volatility decreases significantly in the post-decimalization period. The declines in the return volatility are significant at the 1% level for hot, warm, and cold IPOs for both mean and median. Therefore, the result indicates that decimal pricing leads to a significant decline in volatility for all IPOs.

[Insert Table 4 here]

Intraday Depths and Spreads

Table 5 shows the intraday bid depth, ask depth, relative quoted spread, and relative effective spread on the first day of IPOs aftermarket trading. As the trading activity of IPOs is usually high, especially at the start of trading, the spreads and depths may vary over time, and may have different patterns in the pre- and post-decimalization period. We split the day into 30-minute intervals from 09:30 to 16:00. From Table 5, we find that hot IPOs generally do not start trading immediately at 09:30 as compared to cold IPOs in the pre- and post-decimalization period. This is consistent with the finding of Aggarwal (2000). Most of the hot IPOs in our sample commence trading after 10:00 A.M.

[Insert Table 5 here]

Panel A of Table 5 presents the intraday depths and spreads for hot IPOs. We observe that the bid and ask depth are higher at the opening and closing, exhibiting a U-shape during the day in the pre-decimalization period, while both bid and ask depth do not have such strong pattern in the post-decimalization period. The bid and ask depth are considerably smaller in post-decimalization period, especially for the ask depth. The relative quoted and effective spreads are also, on average, 50% lower throughout the day in the post-decimalization period. However, in both periods, the relative quoted spread is higher at the beginning and at the last hour of trading, while the relative effective spread is higher initially and stable at the lower level over time.

In Panel B of the same table, intraday depths and spreads for warm IPOs are reported. Both the bid and ask depth are higher at the starting and closing in the pre- and post-decimalization period. However, the bid and ask depth do not reduce immediately in the first hour trading in post-decimalization period, and the initial depth is actually higher than pre-decimalization. The relative quoted and effective spreads are smaller throughout the day. The spreads are higher at the first hour of trading, and increase again in the last hour.

Panel C shows the intraday depths and spreads for the cold IPOs. The bid depth is higher at the start of trading, and then stabilizes over time in the pre- and post-decimalization period. However, the ask depth is stable throughout the whole day for both periods. The bid depth at the beginning of trading in the post-decimalization period is higher than that of the pre-decimalization period, while the ask depth in the post-decimalization period is considerably smaller over time compared to pre-decimalization. The relative quoted and effective spreads are unchanged over time, but only slightly higher initially in both periods.

Underwriter Price Support and Short-covering

Underwriter price support is an important source of liquidity for cold IPOs. To provide price stabilization for cold IPOs in aftermarket trading, the underwriter usually takes an initial short position in the shares offering to protect her/his price risk from stock flippers. In addition, if the share price declines below the discounted offer price (offer price minus underwriting spread), underwriters will find it profitable to cover their short position from market purchases.

Boehmer and Fishe (2004) provide evidence that the short-covering trades tend to be seller-initiated, and is positively related to the fraction of trades at the bid. These results indicate that the underwriter is willing to provide liquidity when more sellers are in the market, i.e., in a cold IPO market. Following Boehmer and Fishe (2004)'s argument, we plot the frequency (size) of trades at the bid prices relative to the offering prices of cold IPOs [15] in the pre- and post-decimalization period to examine the underwriter short-covering price support that provides liquidity[16] in aftermarket trading.

Corwin, Harris, and Lipson (2004) document that the underwriter provides price support for cold IPOs through the trading floor to the quoted bid depth. Boehmer and Fishe (2004) find that 81% of the short-covering volume originates from the trading floor, and 79% of trades at the bid results from short-covering trades. Thus, we expect that the limit buy order execution is higher when the underwriter short-covering is likely. To identify the limit orders, we employ the algorithm proposed by Greene (1997). The inferred limit order algorithm looks at the differences between two successive quotes. If the ask and bid remain the same but the depth on the bid decreases, the algorithm looks for a trade or trades that took place at the bid price after the first quote and before the second quote. It then classifies a portion of the trades equal to the difference in depths as having been executed against limit buy orders. If the bid price of the second quote is

[15] Underwriters usually provide price support for cold IPOs by short-covering in aftermarket trading (see Aggarwal (2000) and Boehmer and Fishe (2002, 2004).

[16] Boehmer and Fishe (2004) document that the underwriter generally submits passive buy orders to provide liquidity.

lower than that of the first quote, a portion of the intervening trades which were executed at the original bid price is said to have been executed against limit buy orders. A similar classification is applied to the ask side to identify the execution of limit sell orders. We then plot the number of shares of limit buy orders executed at bid quotes relative to the offering prices of cold IPOs to assess the possibility of short-covering trades.

In the post-decimalization period, where the tick size is just $0.01, the underwriter may face increased selling pressure in cold issues from the stock flippers and the smaller rewards to provide liquidity. Thus, if we observe that the underwriter continues to provide price stabilization for cold IPOs by short-covering in the aftermarket trading, the decimal pricing should not have any significant effects on their short-covering strategy.

Charts A and B of Figure 2 present the frequency of trades at bids relative to offering prices of cold IPOs in the pre- and post-decimalization period, respectively. There is a high frequency of trades at offer price for both the pre- and post-decimalization period. This result is consistent with the finding that the underwriter provides price support at the offer price for cold IPOs (see Ruud (1993) and Hanley, Kumar, and Seguin (1993)). In Chart A, we also observe some clustering of trades around -$0.25 to -$0.5 relative to the offer price in the pre-decimalization period. Similarly, in Chart B, the trades clearly cluster around -$0.3 to -$0.5 which is many ticks (50 ticks) below the offer price in the post-decimalization period. This result is strongly consistent with the short-covering strategy of the underwriter.

Charts C and D plot the volume of trades at bids relative to offering prices of cold IPOs in pre- and post-decimalization, respectively. The patterns are consistent with

Charts A and B in that the short-covering volume is larger at the offer price and between \$-0.25 and \$-0.50 relative to offer price in pre- and post-decimalization.

Charts E and F show the limit buy order volumes executed at bid quotes relative to offering prices of cold IPOs in pre- and post-decimalization, respectively. We observe that the limit buy order execution is higher at the offer price and also when the share price drops substantially below the offer price in pre- and post-decimalization. This interesting result suggests that the underwriter is still the only liquidity provider to support the cold IPOs, and covers their short position from aftermarket purchase when it is still profitable in post-decimalization.

[Insert Figure 2 here]

In Table 6, we test for the underwriter short-covering for cold IPOs in pre- and post-decimalization. We compute the proportion of number of trades (trading volume) at bids as the number of trades (trading volume) at the bid prices relative to the total number of trades (total trading volume) at bids. We then cumulate the proportion of number of trades (trading volume) at bids and group them into six incremental intervals based on the relative prices between IPO trade and offer prices. Consistent with Figure 2, the results show that the proportion of number of trades (trading volume) at bids is higher at the offer price and at farther below the offer price in pre- and post-decimalization. Furthermore, we find that the proportion of number of trades (trading volume) at bids is not significantly different between pre- and post-decimalization for relative prices farther below the offer price (below -\$0.5), suggesting that the underwriter short-covering behavior does not change after decimalization if short-covering is profitable.

In sum, regardless of the decimal pricing or smaller tick size, the results suggest that the underwriter is still the only liquidity provider for cold IPOs, which covers their short position from market purchases and earns an attractive profit from covering farther below the offer price. This implies that the decimalization does not affect the trading strategy of the underwriter in the aftermarket trading for cold IPOs.

[Insert Table 6 here]

Flipping Activity

Previous studies document that institutions flip more than retail investors. To assess the flipping activity in the IPOs aftermarket trading, we use the algorithm of Krigman, Shaw, and Womack (1999) by classifying the seller-initiated trades of greater than 10,000 shares as institutional flipping. The algorithm of Lee and Ready (1991) is used to sign all transaction. The flipping ratio is computed as the first-day sell-signed block-trade dollar volume to total dollar volume traded on the first-day

In addition to the flipping algorithm of Krigman, Shaw, and Womack (1999), we also adopt two more proxies for institutional trading. First, we employ the inferred institutional trading algorithm of Campbell, Ramadorai, and Vuolteenaho (2004) to classify transactions under \$2,000 or over \$30,000 in size as institutional trading.[17] Second, we use the cut-off institutional trading algorithm of Lee and Radhakrishna (2000) to classify all trades over \$20,000 as institutions. We compute these two flipping ratios as the first-day sell-initiated institutional-trade volume to total volume traded.

[17] Campbell, Ramadorai, and Vuolteenaho (2004) note that institutions might break trades into extremely small sizes when they are stealth trading, or institutions are likely to engage in scrum trades to round off an extremely small equity position, and institutions may put in tiny iceberg trades to test the waters before trading in larger size. Aggarwal (2003) documents that institutions split their orders into smaller sizes in order to reduce the price impact.

Table 7 shows that institutions generally flip more cold than hot IPOs in both the pre- and post-decimalization period. In Panel A of the table, institutions flip on average 47% and 40% of total dollar volume of cold IPOs in the pre- and post-decimalization period, respectively, whereas institutions flip less than 30% of hot IPOs for both the pre- and post-decimalization period.[18] However, from Panels A, B, and C of Table 7, we find that institutions do not flip more cold IPOs in the post-decimalization period compared to the pre-decimalization period. This result suggests that decimal pricing does not change the flipping strategy of institutions for cold IPOs as their flipping is most likely bound by underwriter price support and initial shares allocated to them. We also find that institutions tend to flip more hot IPOs in the post-decimalization period (significant at 1% level), indicating that the cost of flipping hot IPOs is much lower than in the pre-decimalization period given that the share prices of hot IPOs shoot up substantially. The results are consistent overall for all three institutional flipping proxies. This result is particularly noteworthy.

[Insert Table 7 here]

In Table 8, we further divide the day into five time intervals: 09:30–10:00, 10:00–11:30, 11:30–14:00, 14:00–15:30, and 15:30–16:00. In Panels A, B, and C of Table 8, we can see that the institutional flipping for hot IPOs in post-decimalization is generally higher than in pre-decimalization throughout the first day of trading. Particularly, the higher institutional flipping of hot IPOs post-decimalization is almost captured in the first two hours of trading, which is also statistically significant at 5% level. This flipping result is also consistent with the notion that sellers in the opening trade are likely to be

[18] Krigman, Shaw, and Womack (1999) find that institutional flipping accounts for 45% and 22% of the total dollar volume of cold and hot IPOs, respectively.

investors who obtained shares in the original offer. However, we do not observe the same pattern for warm and cold IPOs in the post-decimalization period.

[Insert Table 8 here]

Since the trading volume of cold IPOs is relatively lower in the aftermarket trading (Aggarwal (2003)),[19] for a robustness check we compute the flipping ratio as the first-day sell-signed block-trade to total shares offered for our three institutional trading proxies. The results (not reported) show that the institutional flipping based on shares offered for hot IPOs is still higher and significant at the 5% level in the post-decimalization period. However, the institutional flipping for cold IPOs is not different in the pre- and post-decimalization periods.[20] Therefore, our overall results suggest that institutions flip more hot IPOs in the post-decimalization period.

Regression Analysis

In this section, we present a cross-sectional regression analysis to examine whether decimalization affects spread and depth on the first day of an IPOs aftermarket trading. The dependent variables are time-weighted quoted dollar spread, trade-weighted effective dollar spread, and the bid and ask depth. The independent variables include: (1) a dummy variable for the post-decimalization period, which equals to 1 if the IPOs are after decimalization, and zero otherwise; (2) underpricing, measured for hot, warm, and cold IPOs, which is computed based on the offer-to-open returns of IPOs; (3) logarithm

[19] The mean and median of the first day total trading volume for hot (cold) IPOs are 12.64 (9.65) and 8.60 (7.18) million, respectively, in our sample.
[20] The mean values of the shares traded as a proportion of total shares offered on the first trading day are 62.07% and 64.77 % in the pre- and post-decimalization periods, respectively. Aggarwal (2003) reports that the mean of the shares traded as proportion of total shares offered in the first two days is 81.97%. Thus, we eliminate the outliers that the shares traded on the first day is more than 100% of the total shares offered. 5 (8%) and 4 (7%) IPOs are deleted in pre- and post-decimalization, respectively, from the sample.

of average intraday prices; (4) logarithm of average trading volume; (5) logarithm of range defined as the difference between the high and low trade prices divided by the midpoint of the bid-ask prices; (6) logarithm of the number of lead and co-lead managers in IPO activity; and (7) underwriter market shares defined for each lead underwriter as the proportion of the IPO proceeds raised during the sample period.

The regression results are presented in Table 9. The spreads, bid depth, and ask depth are significantly lower at the 5% level in the post-decimalization period. There is a positive relation between spreads and underpricing, but no significant relation between depth and underpricing. The interaction term of the post-decimalization dummy variable and underpricing is negative and significantly related to spreads.[21] This result suggests that the greater the underpricing, the lower the spreads in post-decimalization. This interaction relationship, however, does not hold for the depths, suggesting that the decimal pricing has the same effect on depth for hot, warm, and cold IPOs. The number of lead and co-lead managers proxies for the ability of managers market making in IPOs, and the underwriter market shares proxies for the reputation, are only positive and significant at 5% for the bid depth. This result indicates that the larger size of managers in IPO activity and the higher reputation of the underwriter lead the higher bid depth of IPOs in the aftermarket trading. The price, volume, and range are the control variables in our regression models, and the results are consistent with the previous findings (e.g. Harris (1994)). The adjusted R^2 in all the models, are greater than 63%.

[Insert Table 9 here]

[21] To control for the possible effect of the quoting environment (different tick size) on the underpricing, we adjust the underpricing by regressing the underpricing variable on the binary variable of decimalization for hot, warm, and cold IPOs. The results remain unchanged for all models.

V Sensitivity Analysis

Benchmark

To differentiate the effect of decimalization between IPO and seasoned stocks, we perform a sensitivity test by selecting a set of control firms[22] for our IPO sample. Specifically, we control the effect of seasoned stocks by (1) computing the difference between the effective spreads of IPO and seasoned stocks as the dependent variable of our regression model, and (2) incorporating the effective spreads of the control firms as an independent variable in the regression model.

In Panel A of Table 10, we find that the quoted and effective spreads of hot (cold) IPOs reduce more (less) than those of matched hot (cold) IPOs post-decimalization. In addition, we do not find that the relation between spreads and underpricing of matched IPOs becomes negative after decimalization, which is different from our finding for the IPO firms. Thus, we argue that the spreads of IPO and seasoned stocks do not exhibit the same.

We present the regression results in Panel B of Table 10. In model 1, we compute the dependent variable as the difference between the effective spreads of IPO and seasoned stocks. In model 2, we incorporate the effective spreads of the seasoned stocks as one of the independent variables. The regression results show that the interaction term, *POST*Underpricing*, is still negative and significant at 10% and 1% levels in model 1 and 2, respectively. The spread of control firm (*Control_ESpread*) in model 2 is not significant. This result strengthens our important finding that after controlling for the

[22] Control firms are selected based on (1) non-IPO firms; (2) NYSE; (3) same 2-digit SIC; and (4) similar market capitalization, closing price times shares outstanding, prior to IPO listing day to IPO opening price times shares outstanding. Thus, 230 seasoned stocks are selected as control firms.

possible decimalization effect on the seasoned stocks, the more underpriced IPOs receive the larger reduction in the spreads after decimalization.

NASDAQ-Listed IPOs

In this section, we investigate the IPOs listed on NASDAQ during 1998–2004. We retrieve the NASDAQ-listed IPOs from SDC new issue database. We obtain the final sample of 1189 IPOs. Since decimalization was implemented by NASDAQ on April 9, 2001, we have 935 and 254 IPOs in pre- and post-decimalization period, respectively. The small sample post-decimalization is mainly due to the internet bubble burst in 2001. Based on the offer-to-open returns, we classify the IPOs into 580 hot, 225 warm, and 130 cold IPOs in pre-decimalization, and 95 hot, 125 warm, 34 cold IPOs in post-decimalization.

In Table 11, we observe that the effective spreads of NASDAQ-listed IPOs decrease significantly after decimalization for hot and warm IPOs, but the quoted spreads do not reduce for all IPO categories. It is possible that the investors have no incentive to reveal their quotes post-decimalization. Since the large sell information content in cold IPOs is relatively high, the quoted and effective spreads of cold IPOs do not reduce much after decimalization.

[Insert Table 11 here]

The depths and bid depths are smaller after decimalization for hot and warm IPOs post-decimalization due to the higher probability of front-running. The depths, total depth and bid depth of cold IPOs do not change much after decimalization because of the underwriter price support and institutional trading. The ask depths are generally smaller after decimalization. The number of quotes increases for all IPOs. We find that the trading value decreases after decimalization, and the trading volume decreases mainly for warm and cold IPOs. The number of trades reduces significantly for hot and warm IPOs.

In Table 12, the regression results show that the effective spread reduces significantly after decimalization, but the quoted spread surprisingly increases, suggesting that the investors are unwilling to reveal their interests in trading in the post-decimalization period. The positive relation between underpricing and spreads indicates the different degrees of information content in the IPOs. Contrary to the results of NYSE-listed IPOs, we do not find that the more underpriced IPOs receive the larger reduction in spreads after decimalization, as the interaction term, *Post*Underpricing*, is not significant in the regression models.

The decimalization has a negative impact on the bid and ask depths. The negative and significant *Underpricing* suggests that the more underpriced IPOs the smaller bid and ask depths. Interestingly, the negative and significant relation between the bid (ask) depth and interaction term suggests that the bid (ask) depth of the more underpriced IPOs reduces more than that of less underpriced IPOs post-decimalization. This result supports the evidence of the underwriter price support and the high selling pressure of cold IPOs. The smaller depths of hot IPOs may due to the high adverse selection costs and high probability of front-running.

[Insert Table 12 here]

VI. Summary and Conclusion

While numerous studies document the effect of decimalization on various aspects of the market quality of seasoned stocks, there are no studies that explore how decimalization may affect newly listed securities. In this essay, we provide the first investigation of the effects of decimalization on the aftermarket trading of NYSE-listed IPOs. We find that after decimalization, the relation between spreads and underpricing becomes negative. Hot IPOs receive more reduction in spreads than cold IPOs in the post-decimalization period due to the increase of price competition. The depths are also smaller post-decimalization, especially for the ask depth. This low displayed liquidity is due to the higher probability of front-running in the post-decimalization period, which aggravates the cost of adverse selection at the start of an IPO trading, and that of submitting limit orders.

Consistent with the underwriter price support for cold IPOs hypothesis, we find more trades clustering at and farther below offer price in the pre- and post-decimalization period. This result indicates that the underwriter still provides price support for cold IPOs at offer price, and is only willing to cover the short position when it is still profitable regardless of the smaller tick size that may increase the short-covering cost.

Previous research finds that institutions flip more than retail investors. Using Krigman, Shaw, and Womack (1999)'s algorithm, we find that the decimalization does not alter the flipping strategy of institutions for cold IPOs. Given that the cold IPOs are most likely to be flipped, it is possible that the flipping activity in the aftermarket trading is bound by underwriter price support and the initial shares allocation to institutions. However, we find that institutions tend to flip more hot IPOs post-decimalization than in the pre-decimalization period. This result is due to the lower cost of flipping post-decimalization as the stock prices of hot IPOs usually increase substantially in aftermarket trading.

Because the data on short-covering and flipping are not publicly available, the analyses in this study are restricted to our available data source. However, the results here should be able to provide a better understanding of the effect of decimalization on the IPOs aftermarket trading. Previous studies document that the information contained in the pre-opening of IPO trading is an important determinant of the initial and future returns of IPOs, and IPO firms generally tend to underperform in the long-run. In addition, limit orders information is also an important source of IPO aftermarket liquidity (Corwin, Harris, and Lipson (2004)). Therefore, it may be a fruitful area to examine the effect of decimalization on these issues for future research.

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Table 1 Sample distribution

This table presents the sample distributions of 230 NYSE-listed IPOs by IPO-type, industry, and decimalization. We partition the sample during 1998 – 2004 into pre- and post-decimalization based on the full implementation of decimalization program on NYSE on January 29, 2001. We classify the IPOs as Hot, Warm, and Cold based on the offer-to-open returns. Hot IPOs are those that open above the offer price by more than 10%, warm IPOs open above the offer price by no more than 10%, and cold IPOs open at or below offer price. All IPOs are assigned a Standard and Poors Global Industry Classification Standard (GICS) industry code at the 10-industry sector level.

		Pre-decimalization (1/1/1998 – 1/28/2001)				Post-Decimalization (1/29/2001 – 12/31/2004)			
code	Industry name	All	Hot	Warm	Cold	All	Hot	Warm	Cold
10	Energy	7	2	4	1	14	3	10	1
15	Materials	5	0	0	5	6	2	2	2
20	Industrials	18	9	5	4	14	4	4	6
25	Consumer Discretionary	25	13	5	7	25	13	6	6
30	Consumer Staples	7	2	2	3	4	0	2	2
35	Health Care	9	7	1	1	11	7	1	3
40	Financials	24	10	8	6	27	12	9	6
45	Information Technology	11	5	5	1	11	5	4	2
50	Telecommunication Services	3	2	1	0	1	0	1	0
55	Utilities	5	2	2	1	3	2	1	0
All		114	52	33	29	116	48	40	28

Table 2 Summary statistics for sample

This table presents the descriptive statistics for the 230 NYSE-listed IPOs from 1998 to 2004. We report the offer and firm characteristics for pre- and post-decimalization in Panel A and B, respectively. Net proceeds is the total amount excluding fees and expenses raised by issuers. Gross spread is the percentage of total underwriter's fee to net proceeds. Offer to open (close) returns is the difference between the opening (closing) price and offer price as the percent of the offer price. Filing Price Range is defined as the difference between high and low filing price as the percent of the low filing price. Underwriter market share is defined for each lead underwriter as the proportion of IPO proceeds raised during the sample period. The number of underwriters includes lead and co-lead manager in the IPO activity. The over-allotment shares is the additional shares that issuer allows the underwriter to offer up to 15% more. Market value is defined as post-IPO shares outstanding times the first day closing stock price. The debt to asset ratio equals total debt divided by total assets. Total assets, net sales, total debt, total liabilities, earnings before interests and taxes (EBIT), returns on assets (ROA), returns on operating cash flows (Cash ROA) are based on the most recent fiscal year ending prior to the IPO. For the comparison of the pre- and post-decimalization means and medians, we report the t-statistics and the z-statistics based on Wilcoxon signed ranks test in the parentheses. * and ** represent the 10% and 5% two-tailed significance level, respectively.

	Pre-decimalization (N=114)			Post-decimalization (N=116)			Differences (Post-Pre)	
	Mean	Median	Standard deviation	Mean	Median	Standard deviation	Mean	Median
Panel A: Issue characteristics								
Shares Offered (M)	26.38	11.05	44.55	31.01	14.00	67.20	4.63	2.95*
							(0.62)	(1.87)
Net Proceeds ($M)	509.04	144.86	1,060.38	532.99	212.52	939.99	23.95	67.66***
							(0.18)	(2.79)
Gross Spread	0.07	0.08	0.02	0.07	0.08	0.01	0.00	0.00
							(1.34)	(1.39)
Offer Price	18.73	17.00	9.97	19.16	18.00	7.47	0.43	1.00
							(0.37)	(1.22)
Offer to Open Returns (%)	14.00	8.21	21.53	9.55	7.23	12.16	-4.45*	-0.98
							(-1.93)	(0.87)
Offer to Close Returns (%)	14.80	8.46	24.71	10.67	8.77	13.80	-4.13	0.31
							(-1.57)	(0.36)
Open to Close Returns (%)	0.52	0.00	5.64	1.00	0.34	4.89	0.48	0.34
							(0.68)	(0.81)
Filing Price Range (%)	15.71	14.64	6.43	13.36	13.33	5.78	-2.35***	-1.31***
							(-2.92)	(-4.03)
UW Market Share (%)	8.76	9.60	5.87	9.71	9.26	4.63	0.95	-0.34
							(1.36)	(-0.88)
No. of Underwriters	5.02	4.00	3.15	6.39	5.00	3.59	1.37***	1.00***
							(3.08)	(4.23)
Over-allotment shares (M)	3.39	1.41	6.11	3.19	1.95	3.63	-0.20	0.54**
							(0.30)	(2.40)

Table 2 (continued)

	Pre-decimalization (N=114)			Post-decimalization (N=116)			Differences (Post-Pre)	
	Mean	Median	Standard deviation	Mean	Median	Standard deviation	Mean	Median
Panel B: Firm characteristics								
Market Value ($M)	2,550.66	684.80	5,752.83	2,070.05	973.49	3,451.42	-480.61	288.69**
							(-0.77)	(2.03)
Total Assets ($M)	8,469.25	535.20	33,626.25	7,508.45	774.98	30,703.04	-960.80	239.78**
							(-0.23)	(1.96)
Net Sales ($M)	1,040.52	202.04	2,410.78	1,408.73	375.00	3,502.05	368.21	172.96*
							(0.92)	(1.82)
Total Debt ($M)	2,190.16	160.80	14,521.86	1,461.73	222.70	4,908.02	-728.43	61.90
							(-0.50)	(1.12)
Total Liabilities ($M)	7,261.81	420.99	31,947.57	6,447.96	638.29	28,215.04	-813.85	217.30*
							(-0.20)	(1.65)
EBIT ($M)	128.51	27.00	441.08	91.91	48.35	215.37	-36.60	21.35
							(-0.78)	(1.31)
ROA	2.56	2.08	22.00	7.35	2.69	33.78	4.79	0.61
							(1.24)	(0.02)
Cash ROA	0.09	0.05	0.13	0.10	0.07	0.17	0.01	0.02
							(0.61)	(0.99)
Debt to Asset Ratio	36.93	31.55	32.30	39.40	37.64	35.90	2.47	6.09
							(0.54)	(0.32)

Table 3 Quotes activities of IPO firms before and after decimalization

This table presents the means and medians summary statistics of quotes activities for 230 NYSE-listed IPOs before and after decimalization. We measure quoted and effective spreads in term of dollar and proportion. Quoted spreads are computed based on time-weighted average. Depth is the sum of bid and ask depth measured in terms of dollar and share. Depth imbalance defines as the difference between bid and ask depth stated as a percentage of bid plus ask depth. Bid, ask, share depths are in terms of round lots. Depth, bid depth, ask depth, and depth imbalance are computed based on time-weighted average for each IPO. The number of quotes includes only NYSE quotes. The hot IPOs are those that open above the offer price by more than 10%, warm IPOs open above the offer price by no more than 10%, and cold IPOs open at or below offer price. For the comparison of the pre- and post-decimalization means and medians, we compute the t-statistics and the z-statistics based on Wilcoxon signed ranks test. *, **, and *** represent the 10%, 5%, and 1% two-tailed significance level, respectively.

		Pre-decimalization				Post-decimalization			
		Hot (52)	Warm (33)	Cold (29)	All (114)	Hot (48)	Warm (40)	Cold (28)	All (116)
Quoted dollar spread	Mean	0.1715	0.0983	0.0919	0.1304	0.0717***	0.0458***	0.0446***	0.0565***
	Median	0.1263	0.0969	0.0764	0.1024	0.0612***	0.0443***	0.0394***	0.0504***
Quoted percentage spread	Mean	0.0066	0.0055	0.0066	0.0063	0.0030***	0.0025***	0.0030***	0.0028***
	Median	0.0059	0.0056	0.0051	0.0056	0.0027***	0.0022***	0.0026***	0.0026***
Effective dollar spread	Mean	0.1351	0.0727	0.0761	0.1023	0.0863**	0.0504***	0.0604	0.0680***
	Median	0.0901	0.0658	0.0646	0.0743	0.0669***	0.0414***	0.0507***	0.0514***
Effective percentage spread	Mean	0.0050	0.0040	0.0055	0.0048	0.0035**	0.0027***	0.0047	0.0035***
	Median	0.0044	0.0038	0.0047	0.0042	0.0030***	0.0022***	0.0032***	0.0029***
Depth ($1,000)	Mean	824.88	1,275.81	1,159.82	1,038.74	289.47***	789.51*	483.63***	505.05***
	Median	523.90	861.05	922.52	631.54	211.41***	368.40***	293.76***	267.34***
Depth (round lots)	Mean	360.94	645.67	769.83	545.76	114.23***	453.46	297.63***	272.74***
	Median	200.91	517.19	560.99	331.35	93.28***	178.50***	203.57***	142.11***
Bid Depth (round lots)	Mean	204.45	383.20	472.52	323.34	70.53***	328.52	174.81***	182.73***
	Median	112.15	334.18	424.43	216.16	59.12***	116.74***	123.02***	82.96***
Ask Depth (round lots)	Mean	156.50	262.47	297.31	222.42	43.70***	124.93**	122.82**	90.01***
	Median	83.09	190.41	179.55	113.63	34.94***	59.57***	60.05***	48.30***
Depth Imbalance	Mean	14.87	16.25	19.02	16.31	12.99	15.94	19.60	15.56
	Median	17.52	14.98	19.89	17.53	11.73	14.76	24.82	14.13
Number of Quotes	Mean	992.23	723.70	436.69	775.08	1,836.96***	1,429.58***	1,497.71***	1,618.36***
	Median	672.00	683.00	405.00	622.00	1,628.50***	1,258.50***	1,539.50***	1,467.00***

Table 4 Trading activities of IPO firms before and after decimalization

This table presents the means and medians summary statistics of trading activities, and the components of spreads for 230 NYSE-listed IPOs before and after decimalization. Returns volatility is the standard deviation of intraday returns. The number of trades is the total number of transaction. Trading volume is the average trade size, and trading value is the average of the product of price and quantity traded. Trade at bid and ask are those transactions occurred at bid and ask price, respectively, which are measured in terms of share, trading volume, and number of trades. Trade inside spread is the proportion of number of transactions occurs between bid and ask prices. The hot IPOs are those that open above the offer price by more than 10%, warm IPOs open above the offer price by no more than 10%, and cold IPOs open at or below offer price. For the comparison of the pre- and post-decimalization means and medians, we compute the t-statistics and the z-statistics based on Wilcoxon signed ranks test. *, **, and *** represent the 10%, 5%, and 1% two-tailed significance level, respectively.

		Pre-decimalization				Post-decimalization			
		Hot (52)	Warm (33)	Cold (29)	All (114)	Hot (48)	Warm (40)	Cold (28)	All (116)
Number of Trades	Mean	3,521.11	2,727.58	984.83	2,653.82	2,671.14	2,010.53	1,553.68**	2,182.04
	Median	1,219.00	963.00	688.00	979.00	1,814.50***	1,472.00*	1,331.50***	1,647.50***
Returns Volatility	Mean	0.0037	0.0026	0.0034	0.0033	0.0019***	0.0015***	0.0016***	0.0017***
	Median	0.0029	0.0024	0.0027	0.0026	0.0018***	0.0014***	0.0015***	0.0015***
Trade Size									
Dollar Volume	Mean	147.06	126.16	126.46	135.87	109.56*	138.22	99.97	117.00
($1,000)	Median	113.26	99.36	121.53	108.53	84.42*	101.52	99.65	94.65
Share Volume	Mean	57.00	66.38	78.10	65.01	44.25**	70.58	61.71	57.32
(round lots)	Median	50.55	58.12	70.34	58.12	38.61**	50.70	60.84	46.58*
Trade Volume at Bid	Mean	38.20	51.27	73.00	50.73	37.02	70.74	62.45	54.49
(round lots)	Median	30.38	44.41	50.81	37.58	31.27	46.45	59.54	40.90
Trade Volume at Ask	Mean	34.75	39.64	20.76	32.73	40.65	56.61**	43.20***	46.67***
(round lots)	Median	30.97	31.68	19.05	28.52	32.27	51.92**	37.73***	37.19***
Proportion of Trade at Bid	Mean	19.75	29.80	47.14	29.54	22.61*	28.29	35.81**	27.66
(%)	Median	17.88	29.24	45.84	22.91	21.94**	28.00	30.76**	24.92
Proportion of Trade at Ask	Mean	15.12	15.16	12.08	14.38	19.48***	19.06***	15.39	18.37***
(%)	Median	13.84	14.37	11.02	13.72	17.91***	19.51***	15.24*	17.88***
Number of Trade									
Trade at Bid (%)	Mean	30.31	37.99	49.80	37.43	26.12**	30.52**	35.84***	29.92***
	Median	30.02	38.98	44.45	33.11	25.05*	30.02**	29.87**	27.76***
Trade at Ask (%)	Mean	24.39	29.89	31.78	27.80	21.53*	22.68***	22.00***	22.03***
	Median	22.12	30.00	29.89	25.46	21.01	21.97**	23.38**	21.47***
Trade inside Spread (%)	Mean	42.58	30.46	20.15	33.81	47.64**	42.67***	38.48***	43.78***
	Median	42.67	32.23	19.93	34.09	45.88**	42.78***	39.67***	42.89***

Table 5 Intraday Bid Depth, Ask Depth, Quoted Spread, and Effective Spread before and after decimalization

The table shows the means (medians) for the bid depth, ask depth, quoted spread, and effective spread for 122 NYSE-listed IPOs before and after decimalization. The mean and median values are based on 30-minute intervals from 9:30 A.M. to 4:00 P.M. Bid, ask depth are in terms of round lots. We compute the intraday time weighted quoted spread as a proportion of share price, $[(A_{i,t} - B_{i,t})/M_{i,t}]$. Effective spread is defined as a proportion of share price, $[2 \cdot D_{i,t} \cdot (P_{i,t} - M_{i,t})/ M_{i,t}]$. Results for hot, warm, and cold IPOs are presented in panels A, B, and C, respectively, where hot IPOs are those that open above the offer price by more than 10%, warm IPOs open above the offer price by no more than 10%, and cold IPOs open at or below offer price.

Panel A: Hot IPOs

	Pre-decimalization					Post-decimalization				
	# of IPOs	Bid	Ask	QSpread	ESpread	# of IPOs	Bid	Ask	QSpread	ESpread
09:30 - 10:00	22	237.14	149.16	0.0090	0.0046	32	267.96	123.78	0.0051	0.0036
		(165.20)	(98.13)	(0.0090)	(0.0043)		(107.24)	(72.09)	(0.0047)	(0.0033)
10:00 - 10:30	45	349.27	153.03	0.0092	0.0055	48	154.79	77.59	0.0042	0.0028
		(178.49)	(109.70)	(0.0081)	(0.0044)		(86.03)	(56.10)	(0.0042)	(0.0025)
10:30 - 11:00	52	241.55	157.40	0.0085	0.0042	48	91.12	54.83	0.0031	0.0018
		(139.06)	(108.71)	(0.0066)	(0.0033)		(55.44)	(43.72)	(0.0030)	(0.0020)
11:00 - 11:30	52	199.02	161.69	0.0066	0.0076	48	76.97	47.10	0.0028	0.0017
		(113.84)	(97.25)	(0.0062)	(0.0031)		(49.89)	(34.40)	(0.0027)	(0.0016)
11:30 - 12:00	52	174.48	166.51	0.0058	0.0063	48	62.00	42.64	0.0027	0.0017
		(107.15)	(81.99)	(0.0055)	(0.0031)		(49.03)	(28.96)	(0.0025)	(0.0015)
12:00 - 12:30	52	156.16	155.25	0.0059	0.0039	48	62.10	36.17	0.0028	0.0017
		(101.34)	(75.20)	(0.0055)	(0.0032)		(40.16)	(29.41)	(0.0025)	(0.0017)
12:30 - 13:00	52	159.51	113.51	0.0055	0.0033	48	58.79	33.23	0.0027	0.0015
		(71.17)	(69.17)	(0.0051)	(0.0030)		(37.43)	(27.58)	(0.0022)	(0.0014)
13:00 - 13:30	52	170.68	97.77	0.0052	0.0033	48	50.66	35.42	0.0025	0.0016
		(75.06)	(54.86)	(0.0051)	(0.0028)		(34.81)	(26.28)	(0.0024)	(0.0015)
13:30 - 14:00	52	189.49	143.99	0.0055	0.0035	48	50.49	29.00	0.0026	0.0015
		(87.52)	(61.95)	(0.0046)	(0.0030)		(34.22)	(24.21)	(0.0025)	(0.0014)
14:00 - 14:30	52	155.16	164.74	0.0055	0.0033	48	43.81	33.08	0.0026	0.0016
		(64.33)	(49.21)	(0.0052)	(0.0031)		(29.94)	(26.11)	(0.0025)	(0.0015)
14:30 - 15:00	52	185.74	184.91	0.0057	0.0033	48	44.12	30.11	0.0027	0.0017
		(90.59)	(53.63)	(0.0055)	(0.0031)		(32.47)	(27.15)	(0.0023)	(0.0015)
15:00 - 15:30	52	164.62	181.35	0.0058	0.0033	48	66.49	30.89	0.0029	0.0039
		(83.28)	(52.46)	(0.0054)	(0.0031)		(35.66)	(23.54)	(0.0028)	(0.0018)
15:30 - 16:00	52	199.95	187.64	0.0062	0.0036	48	47.47	34.12	0.0030	0.0020
		(83.43)	(52.84)	(0.0051)	(0.0031)		(40.22)	(26.99)	(0.0030)	(0.0018)

Panel B: Warm IPOs

	Pre-decimalization					Post-decimalization				
	# of IPOs	Bid	Ask	QSpread	ESpread	# of IPOs	Bid	Ask	QSpread	ESpread
09:30 - 10:00	27	442.14	214.73	0.0077	0.0040	33	660.08	230.90	0.0040	0.0028
		(340.31)	(175.65)	(0.0071)	(0.0043)		(140.55)	(83.83)	(0.0031)	(0.0023)
10:00 - 10:30	33	393.80	313.86	0.0070	0.0043	39	798.53	214.08	0.0031	0.0019
		(274.26)	(204.29)	(0.0063)	(0.0042)		(106.41)	(96.07)	(0.0029)	(0.0018)
10:30 - 11:00	33	381.30	292.84	0.0059	0.0042	39	313.81	121.74	0.0025	0.0017
		(279.75)	(171.44)	(0.0055)	(0.0039)		(85.03)	(69.17)	(0.0022)	(0.0014)
11:00 - 11:30	33	339.29	307.10	0.0054	0.0038	39	194.65	114.46	0.0023	0.0020
		(226.25)	(157.88)	(0.0052)	(0.0035)		(73.66)	(54.80)	(0.0022)	(0.0012)
11:30 - 12:00	33	310.61	307.83	0.0050	0.0032	39	164.23	117.11	0.0025	0.0015
		(195.90)	(101.81)	(0.0051)	(0.0033)		(76.56)	(47.67)	(0.0023)	(0.0014)
12:00 - 12:30	33	401.62	240.91	0.0050	0.0034	39	140.87	89.16	0.0024	0.0015
		(217.16)	(128.98)	(0.0046)	(0.0034)		(78.82)	(51.00)	(0.0020)	(0.0012)
12:30 - 13:00	33	344.38	208.63	0.0050	0.0035	39	134.08	84.74	0.0021	0.0014
		(206.06)	(111.79)	(0.0045)	(0.0033)		(86.41)	(49.47)	(0.0018)	(0.0012)

13:00 - 13:30	33	313.77	219.49	0.0054	0.0039	38	160.82	85.59	0.0023	0.0014
		(244.20)	(156.82)	(0.0050)	(0.0034)		(69.37)	(64.05)	(0.0020)	(0.0012)
13:30 - 14:00	33	320.22	207.65	0.0053	0.0039	40	156.24	110.20	0.0022	0.0014
		(198.15)	(127.19)	(0.0051)	(0.0034)		(69.89)	(46.70)	(0.0020)	(0.0012)
14:00 - 14:30	33	307.71	246.53	0.0052	0.0034	40	201.35	142.39	0.0024	0.0015
		(199.24)	(123.61)	(0.0047)	(0.0033)		(60.93)	(58.49)	(0.0021)	(0.0014)
14:30 - 15:00	33	415.91	225.76	0.0050	0.0035	40	374.63	121.76	0.0023	0.0014
		(241.27)	(99.33)	(0.0048)	(0.0033)		(76.11)	(62.11)	(0.0021)	(0.0012)
15:00 - 15:30	33	378.17	187.54	0.0054	0.0032	40	354.43	114.62	0.0024	0.0015
		(247.37)	(124.29)	(0.0050)	(0.0033)		(78.35)	(43.95)	(0.0021)	(0.0012)
15:30 - 16:00	33	413.35	221.79	0.0052	0.0036	40	725.74	153.35	0.0026	0.0016
		(209.81)	(121.00)	(0.0045)	(0.0034)		(145.74)	(56.32)	(0.0022)	(0.0013)

Panel C: Cold IPOs

	Pre-decimalization					Post-decimalization				
	# of IPOs	Bid	Ask	QSpread	ESpread	# of IPOs	Bid	Ask	QSpread	ESpread
09:30 - 10:00	23	631.37	231.58	0.0081	0.0046	23	526.39	160.95	0.0036	0.0079
		(504.69)	(123.58)	(0.0058)	(0.0043)		(364.17)	(82.04)	(0.0027)	(0.0016)
10:00 - 10:30	24	643.51	348.94	0.0068	0.0051	26	347.61	118.47	0.0033	0.0072
		(288.67)	(169.60)	(0.0053)	(0.0043)		(193.66)	(66.85)	(0.0028)	(0.0020)
10:30 - 11:00	24	422.75	277.41	0.0065	0.0047	26	201.74	85.41	0.0029	0.0018
		(269.11)	(184.32)	(0.0062)	(0.0043)		(81.46)	(64.41)	(0.0027)	(0.0019)
11:00 - 11:30	24	419.16	249.86	0.0063	0.0049	26	104.73	79.27	0.0028	0.0016
		(298.73)	(101.41)	(0.0050)	(0.0043)		(57.45)	(36.45)	(0.0024)	(0.0015)
11:30 - 12:00	27	445.88	286.94	0.0070	0.0054	26	126.97	95.69	0.0026	0.0018
		(329.73)	(133.06)	(0.0052)	(0.0044)		(79.20)	(40.79)	(0.0023)	(0.0015)
12:00 - 12:30	27	473.43	328.55	0.0062	0.0048	26	88.14	84.22	0.0027	0.0017
		(331.93)	(199.79)	(0.0049)	(0.0043)		(68.14)	(46.01)	(0.0024)	(0.0015)
12:30 - 13:00	27	406.13	303.75	0.0057	0.0046	26	96.02	63.84	0.0029	0.0020
		(299.06)	(192.53)	(0.0048)	(0.0042)		(52.38)	(48.16)	(0.0023)	(0.0016)
13:00 - 13:30	28	419.55	282.73	0.0067	0.0056	27	138.59	108.31	0.0037	0.0023
		(182.07)	(139.27)	(0.0051)	(0.0044)		(66.44)	(43.73)	(0.0023)	(0.0015)
13:30 - 14:00	28	391.00	252.32	0.0063	0.0051	28	167.52	122.16	0.0030	0.0021
		(182.82)	(114.63)	(0.0049)	(0.0043)		(69.03)	(53.06)	(0.0023)	(0.0017)
14:00 - 14:30	28	447.90	300.19	0.0060	0.0050	28	153.21	111.45	0.0028	0.0058
		(268.06)	(143.50)	(0.0051)	(0.0042)		(56.60)	(45.96)	(0.0025)	(0.0015)
14:30 - 15:00	28	406.89	303.77	0.0065	0.0052	28	190.90	176.20	0.0031	0.0018
		(202.26)	(115.80)	(0.0053)	(0.0044)		(69.00)	(41.71)	(0.0024)	(0.0018)
15:00 - 15:30	29	407.47	290.27	0.0068	0.0052	28	147.66	196.21	0.0028	0.0016
		(262.40)	(111.00)	(0.0048)	(0.0044)		(50.28)	(38.87)	(0.0026)	(0.0014)
15:30 - 16:00	29	460.76	275.59	0.0059	0.0059	28	215.40	240.75	0.0028	0.0021
		(328.47)	(139.20)	(0.0051)	(0.0044)		(86.81)	(42.98)	(0.0024)	(0.0019)

Table 6 Test for underwriter short-covering before and after decimalization

This table tests for the underwriter short-covering for cold IPOs in pre- and post-decimalization. The relative price (RP) is the difference between trade price and offering price. The RP is grouped into six cumulative intervals. We compute the proportion of number of trades at bids as the number of trades at the bid prices relative to the total number of trades at bids. The proportion of trading volume at bids is defined as the trading volume at bids as proportion to total trading volume at bids. The t-statistics for mean and z-statistics based on Wilcoxon signed ranks test for median are presented in the parentheses. *, **, and *** denote the independent sample test for the difference between means or medians in pre- and post-decimalization, and represent the 10%, 5%, and 1% two-tailed significance level, respectively.

	Pre-decimalization		Post-decimalization		Difference (Post-Pre)	
Relative price (RP) cumulative interval	mean	median	mean	median	mean	median
Panel A Proportion of number of trades at bids						
RP = 0	0.521	0.422	0.229	0.145	-0.292***	-0.277**
					(3.14)	(-2.13)
-0.0625 <= RP <= 0	0.531	0.422	0.264	0.148	-0.267***	-0.274**
					(2.86)	(-2.13)
-0.13 <= RP <= 0	0.489	0.423	0.272	0.212	-0.217**	-0.211
					(2.40)	(-1.45)
-0.25 <= RP <= 0	0.526	0.445	0.301	0.160	-0.225**	-0.285*
					(2.52)	(-1.92)
-0.50 <= RP <= 0	0.616	0.770	0.477	0.397	-0.139	-0.373*
					(1.37)	(-1.68)
RP<=0	0.717	0.981	0.612	0.974	-0.105	-0.007
					(1.03)	(-0.98)
Panel B Proportion of trading volume at bids						
RP = 0	0.700	0.834	0.477	0.475	-0.223***	-0.359***
					(2.68)	(-2.71)
-0.0625 <= RP <= 0	0.703	0.835	0.497	0.475	-0.206**	-0.360***
					(2.51)	(-2.59)
-0.13 <= RP < 0	0.641	0.747	0.506	0.475	-0.135	-0.272*
					(1.61)	(-1.70)
-0.25 <= RP <= 0	0.704	0.811	0.492	0.467	-0.212**	-0.344***
					(2.64)	(-2.78)
-0.50 <= RP <= 0	0.766	0.868	0.634	0.671	-0.132	-0.197**
					(1.66)	(-2.01)
RP<=0	0.847	0.848	0.749	0.926	-0.098	0.078
					(1.40)	(1.04)

Table 7 Flipping ratio of IPOs aftermarket trading

This table presents the flipping ratio for hot, warm, and cold IPOs pre- and post-decimalization. In Panel A, using the Krigman et al. (1999) algorithm, we compute the flipping ratio as the first-day sell-signed block-trade dollar volume to total dollar volume traded on the first-day. The Block-trade is defined as transactions of 10,000 shares or more. Non-institution flipping is defined as sell-signed trades of smaller than 10,000 shares. In Panel B, employing the Campbell et al. (2004) algorithm of institutional trading, we compute the flipping ratio as the first-day sell-initiated institutional-trade volume to total volume trade. Institutional-trade is defined as transactions under $2,000 or over $30,000 in size. In Panel C, we use the Lee and Radhakrishna (2000) algorithm to classify all trades over $20,000 as institutions. Lee and Ready (1991) algorithm is used to sign all transaction. For the comparison of the pre- and post-decimalization means and medians, we compute the t-statistics and the z-statistics based on Wilcoxon signed ranks test. *, **, and *** represent the 10%, 5%, and 1% two-tailed significance level, respectively.

		Pre-decimalization				Post-decimalization			
		Hot (52)	Warm (33)	Cold (29)	All (114)	Hot (58)	Warm (40)	Cold (28)	All (116)
Panel A Krigman et al. (1999)'s algorithm									
Institution Flipping (%)	Mean	23.15	29.23	40.64	29.21	27.83**	31.71	37.89	31.54
	Median	20.36	27.42	35.41	24.39	27.50***	30.87	36.55	29.56***
Non-institution Flipping (%)	Mean	13.33	12.46	15.30	13.58	16.02**	14.34	14.45	15.06
	Median	12.48	12.09	11.72	12.15	16.02**	14.69	11.97	14.94*
Panel B Campbell et al. (2004)'s algorithm									
Institution Flipping (%)	Mean	32.98	38.16	49.36	38.60	39.53***	41.95	45.60	41.83*
	Median	29.46	35.40	45.84	32.94	38.60***	41.18**	44.09	40.04***
Non-institution Flipping (%)	Mean	3.62	3.66	5.29	4.05	4.39	4.16	5.48	4.57
	Median	3.19	3.24	3.53	3.28	4.08**	3.44	3.55	3.67*
Panel C Lee and Radhakrishna (2000)'s algorithm									
Institution Flipping (%)	Mean	34.00	39.11	50.75	39.69	41.08***	43.17	48.06	43.45*
	Median	30.52	36.55	48.03	33.55	40.46***	42.01**	47.35	41.40***
Non-institution Flipping (%)	Mean	2.59	2.71	3.90	2.95	2.84	2.93	4.73	3.33
	Median	2.40	2.22	2.25	2.25	2.69	2.13	2.71	2.38

Table 8 Intraday Pattern of Institutional Flipping

This table plots the intraday means and medians of the institutional flipping. The mean and median values are based on Five intraday intervals from 9:30 A.M. to 4:00 P.M. Hot IPOs are those that open above the offer price by more than 10%, warm IPOs open above the offer price by no more than 10%, and cold IPOs open at or below offer price. We test the means and medians between pre- and post-decimalization by t-test and Wilcoxon signed ranks test, respectively. * and ** represent the 10% and 5% two-tailed significance level, respectively.

		Pre-decimalization				Post-decimalization			
Intraday Interval		Hot (52)	Warm (33)	Cold (29)	All (114)	Hot (58)	Warm (40)	Cold (28)	All (116)
Panel A Krigman et al. (1999)'s algorithm									
09:30 – 10:00	Mean	14.85	22.75	39.04	26.13	21.84	21.04	47.50	28.33
	Median	8.81	12.19	27.14	12.76	17.43**	16.70	38.88	21.20**
10:00 – 11:30	Mean	26.39	33.42	43.02	32.18	32.49**	35.75	36.99	34.63
	Median	20.58	32.87	36.53	27.90	31.40***	31.08	33.84	31.67*
11:30 – 14:00	Mean	28.79	39.47	39.36	34.30	25.68	34.06	29.11*	29.32**
	Median	29.42	38.48	33.30	32.50	25.70	35.19	23.84*	27.88*
14:00 – 15:30	Mean	25.88	37.23	47.78	34.77	25.62	31.75	26.19***	27.93***
	Median	24.70	37.18	44.77	29.68	25.74	30.23	19.93***	27.48**
15:30 – 16:00	Mean	34.13	41.97	46.24	39.40	29.53	40.69	35.43*	34.76
	Median	28.67	38.72	50.64	35.72	24.49	40.57	34.70*	31.88
Panel B Campbell et al. (2004)'s algorithm									
09:30 – 10:00	Mean	17.15	25.70	43.49	29.12	25.27	25.16	50.14	31.88
	Median	11.07	14.71	33.36	18.15	21.35**	21.75	46.86	25.43*
10:00 – 11:30	Mean	36.63	45.42	58.08	44.07	44.51**	47.96	47.33	46.34
	Median	30.31	47.07	53.91	44.56	43.21***	46.80	42.93*	45.44
11:30 – 14:00	Mean	46.89	54.02	52.75	50.40	42.32*	46.36**	41.63*	43.55***
	Median	49.77	51.54	48.35	50.36	41.13*	48.04*	36.29*	43.00***
14:00 – 15:30	Mean	42.65	51.90	65.90	51.04	41.35	45.00	41.16***	42.57***
	Median	40.06	53.25	66.74	47.36	43.92	41.63*	39.92***	41.99***
15:30 – 16:00	Mean	50.59	56.18	62.87	55.22	46.75	56.28	44.70**	49.54*
	Median	53.55	55.86	61.22	55.13	48.87	61.53	40.65**	49.32*
Panel C Lee and Radhakrishna (2000)'s algorithm									
09:30 – 10:00	Mean	16.12	26.27	44.32	28.93	25.72	26.02	52.66	32.73
	Median	10.33	14.72	34.81	18.73	21.38***	22.61	47.43	26.64**
10:00 – 11:30	Mean	37.71	46.77	60.56	45.55	45.98**	49.49	48.81*	47.83
	Median	32.08	50.26	55.33	47.28	45.70**	50.89	44.69*	47.14
11:30 – 14:00	Mean	49.01	56.17	54.90	52.53	44.71	48.27**	44.47*	45.89***
	Median	52.17	55.13	51.76	52.45	44.52	48.68*	38.65	45.16***
14:00 – 15:30	Mean	45.06	53.46	68.99	53.37	44.39	47.16	43.64***	45.18***
	Median	41.73	54.85	70.44	49.54	45.95	44.30	39.71***	45.91***
15:30 – 16:00	Mean	53.77	58.22	66.28	58.17	49.28	58.45	48.39**	52.26**
	Median	54.55	56.21	67.27	58.31	51.57	62.21	43.98***	52.98*

Table 9 Regression Results

The dependent variables, *QSpread*, *ESpread*, and *Bid* (*Ask*) *Depth* denote the time-weighted quoted dollar spread, trade-weighted effective dollar spread, and the bid (ask) quoted share depth, respectively. Price is the average trade price. Volume is the trading volume. Range is the difference between the high and low trade prices divided by the midpoint of the bid-ask prices. Underpricing is the offer-to-open returns defined as (open price – offer price)/offer price*100. Post is a binary variable indicating the decimal era (January 29, 2001 – December, 31, 2004). Number of underwriters is the number of lead and co-lead managers in the IPO activity. UW market share is defined for each lead underwriter as the proportion of IPO proceeds raised during the sample period. t-statistics are shown in the parentheses. **, and *** represent the 5%, and 1% two-tailed significance level, respectively.

	QSpread			ESpread			Bid Depth			Ask Depth		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Intercept	0.1914	0.1657	0.1516	0.3280	0.3001	0.3005	-2.7707	-2.8000	-2.6797	-4.0714	-4.0958	-3.9164
	(2.94)**	(2.23)**	(2.02)**	(4.07)***	(3.86)***	(3.81)***	(-4.75)***	(-4.76)***	(-4.01)***	(-8.88)***	(-8.85)***	(-7.48)***
Post	-0.0683	-0.0416	-0.0373	-0.0305	-0.0014	-0.0015	-0.8288	-0.8055	-0.8185	-0.9774	-0.9580	-0.9819
	(-7.18)***	(-3.74)***	(-3.21)***	(-3.06)***	(-0.12)	(-0.12)	(-10.67)***	(-8.50)***	(-8.23)***	(-16.00)***	(-12.86)***	(-12.59)***
Underpricing	0.1936	0.2450	0.2353	0.1913	0.2473	0.2493	-1.0201	-0.9749	-0.9616	-0.3757	-0.3380	-0.3290
	(5.63)***	(6.94)***	(6.61)***	(5.31)***	(6.70)***	(6.65)***	(-3.68)***	(-3.28)***	(-3.17)***	(-1.72)*	(-1.45)	(-1.39)
Log(Price)	0.036	0.0448	0.0544	0.0263	0.0360	0.0348	-0.7947	-0.7872	-0.8007	-0.6007	-0.5945	-0.6137
	(2.66)***	(3.39)***	(3.77)***	(1.85)*	(2.60)***	(2.29)**	(-6.76)***	(-6.61)***	(-6.41)	(-6.50)***	(-6.35)***	(-6.27)***
Log(Volume)	-0.0159	-0.0168	-0.0155	-0.0338	-0.0348	-0.0347	0.5768	0.5768	0.5678	0.5891	0.5892	0.5755
	(-1.96)**	(-2.15)**	(-1.96)**	(-3.98)***	(-4.26)***	(-4.18)***	(16.05)***	(16.02)***	(13.27)***	(20.84)***	(20.81)***	(17.16)***
Log(Range)	0.0200	0.0201	0.0203	0.0137	0.0139	0.0138	-0.5219	-0.5217	-0.5200	-0.5304	-0.5302	-0.5268
	(2.93)***	(3.05)***	(3.10)***	(1.92)*	(2.02)**	(2.00)**	(-9.59)***	(-9.57)***	(-9.47)***	(-12.39)***	(-12.36)***	(-12.24)***
Post * Underpricing		-0.2578	-0.2693		-0.2810	-0.2801		-0.2238	-0.1890		-0.1869	-0.1293
		(-4.24)***	(-4.40)***		(-4.42)***	(-4.35)***		(-0.43)	(-0.36)		(-0.46)	(-0.31)
Log(No. of Underwriters)			-0.0091			-0.0011			0.0483			0.0981
			(-0.82)			(-0.09)			(0.46)			(1.18)
UW market share			-0.0011			0.0004			-0.0009			-0.0051
			(-1.21)			-0.42			(-0.12)			(-0.79)
F-statistics	41.68***	40.35***	30.84***	28.96***	29.39***	21.88***	103.75***	86.18***	64.14***	164.40***	136.56***	102.47***
Adj. R^2	0.469	0.507	0.509	0.378	0.426	0.421	0.691	0.690	0.687	0.780	0.780	0.779

Table 10 Sensitivity Analysis – Benchmark

This table presents the sensitivity analysis for NYSE-listed IPOs. In Panel A, we calculate the spreads for IPO matched firms. The quoted spreads are computed based on time-weighted average, and the effective spreads are computed based on trade-weighted average. In Panel B, we run the regression to incorporate the seasoned stocks' spreads into the model. In model 1 of Panel B, the dependent variable Diff_Spread is the difference between the effective dollar spreads of IPO and seasoned stocks. In model 2 of Panel B, we control the seasoned stocks' spreads as one of the independent variables in the model. The independent variables include: Price is the average trade price. Volume is the trading volume. Range is the difference between the high and low trade prices divided by the midpoint of the bid-ask prices. Underpricing is the offer-to-open returns defined as (open price – offer price)/offer price*100. Post is a binary variable indicating the decimal era (January 29, 2001 – December, 31, 2004). Number of underwriters is the number of lead and co-lead managers in the IPO activity. UW market share is defined for each lead underwriter as the proportion of IPO proceeds raised during the sample period. Control_ESpread is the effective dollar spreads of the control firms. t-statistics are shown in the parentheses. **, and *** represent the 5%, and 1% two-tailed significance level, respectively.

Panel A Spreads for matched firms

		Pre-decimalization				Post-decimalization			
		Hot	Warm	Cold	All	Hot	Warm	Cold	All
Quoted dollar spread	mean	0.1636	0.1799	0.1783	0.1719	0.1064	0.0981***	0.0949***	0.1008***
	median	0.1562	0.1718	0.1925	0.1655	0.0492***	0.0538***	0.0530***	0.0530***
Quoted percentage spread	mean	0.0087	0.0089	0.0094	0.0089	0.0040***	0.0046**	0.0029***	0.0039***
	median	0.0068	0.0067	0.0075	0.0069	0.0023***	0.0027***	0.0022***	0.0025***
Effective dollar spread	mean	0.1026	0.1233	0.1255	0.1146	0.0987	0.0741***	0.0826*	0.0864*
	median	0.0963	0.1124	0.1231	0.1042	0.0419***	0.0408***	0.0467***	0.0419***
Effective percentage spread	mean	0.0059	0.0068	0.0075	0.0066	0.0072	0.0036**	0.0028***	0.0049
	median	0.0045	0.0045	0.0045	0.0045	0.0020***	0.0018***	0.0019***	0.0019***

Panel B Regression Analysis for spreads adjusted for control firms

Model 1:

Diff_Spread = 0.1431 + 0.0236 POST + 0.2661 Underpricing + 0.0398 Log(Price) - 0.0267 Log(Volume) + 0.0236 Log(Range) - 0.2445 POST*Underpricing
(0.82) (0.93) (3.48)*** (1.28) (-1.44) (1.67)* (-1.73)*

+ 0.0024 Log(No. of Underwriters) - 0.0017 UW market share
(0.10) (-0.81)

F-statistic = 6.04***
$R^2 = 0.153$

Model 2:

ESpread = 0.2273 - 0.0050 POST + 0.2552 Underpricing + 0.0382 Log(Price) - 0.0265 Log(Volume) + 0.0166 Log(Range) - 0.2285 POST*Underpricing
(2.60)*** (-0.39) (6.73)*** (2.43)** (-2.86)*** (2.31)** (-3.25)***

- 0.0038 Log(No. of Underwriters) + 0.0005 UW market share + 0.0268 Control_ESpread
(-0.32) (0.49) (0.71)

F-statistic = 19.43***
$R^2 = 0.430$

Table 11 Quoting and Trading Activities of Nasdaq-Listed IPO

This table presents the means and medians of quotes activities for 1189 NASDAQ-listed IPOs before and after decimalization. In Panel A, we measure quoted and effective spreads in term of dollar and proportion. Quoted spreads are computed based on time-weighted average. Depth is the sum of bid and ask depth measured in terms of dollar and share. Bid, ask, share depths are in terms of round lots. Depth, bid depth, and ask depth are computed based on time-weighted average for each IPO. The number of quotes includes only all quotes. The trading value, trading volume, number of trades, and range are presented in Panel B. The hot IPOs are those that open above the offer price by more than 10%, warm IPOs open above the offer price by no more than 10%, and cold IPOs open at or below offer price. For the comparison of the pre- and post-decimalization means and medians, we compute the t-statistics and the z-statistics based on Wilcoxon signed ranks test. *, **, and *** represent the 10%, 5%, and 1% two-tailed significance level, respectively.

Panel A Quoting Activities

		Pre-decimalization				Post-decimalization			
		Hot (580)	Warm (225)	Cold (130)	All (935)	Hot (95)	Warm (125)	Cold (34)	All (254)
Panel A Quoting Activities									
Quoted dollar spread	mean	0.1335	0.0975	0.0795	0.1173	0.1391	0.1117*	0.1072**	0.1214
	median	0.1137	0.0820	0.0728	0.0976	0.1147	0.0951	0.0885	0.1001
Quoted percentage spread	mean	0.0053	0.0090	0.0076	0.0065	0.0085***	0.0103	0.0098*	0.0096***
	median	0.0045	0.0071	0.0066	0.0053	0.0066***	0.0086	0.0083	0.0078***
Effective dollar spread	mean	0.2451	0.1115	0.0923	0.1917	0.1062***	0.0826***	0.0861	0.0919***
	median	0.1901	0.0998	0.0899	0.1457	0.1014***	0.0654***	0.0781*	0.0779***
Effective percentage spread	mean	0.0082	0.0100	0.0087	0.0087	0.0064***	0.0075***	0.0077	0.0071***
	median	0.0074	0.0089	0.0080	0.0078	0.0053***	0.0066***	0.0068**	0.0062***
Depth ($1,000)	mean	542.20	475.87	569.26	530.00	265.78***	281.45**	604.93	318.89***
	median	517.89	325.44	344.06	387.44	230.54***	197.22***	311.71	202.06***
Depth (round lots)	mean	192.27	388.80	507.89	283.45	143.60***	236.46***	472.29	233.30
	median	195.13	282.34	311.57	192.66	129.74***	164.48***	284.76	143.23***
Bid Depth (round lots)	mean	92.07	216.12	298.97	150.69	74.12*	150.13	340.77	147.22
	median	101.15	145.54	162.15	83.85	62.50***	82.47***	129.14	68.29***
Ask Depth (round lots)	mean	100.20	172.68	208.92	132.76	69.48***	86.33***	131.52***	86.08***
	median	87.98	132.23	145.22	98.42	62.79***	76.58***	102.68***	70.62***
Number of Quotes	mean	30,238.14	10,790.22	9,531.69	22,679.19	43,310.42***	23,798.88***	22,825.00***	30,966.14***
	median	28,955.00	6,370.00	6,800.00	18,080.00	37,590.00***	22,090.00***	21,260.00***	26,355.00***
Panel B Trading Activities									
Trading Value	mean	20,072.33	20,277.76	21,146.63	20,271.13	15,091.45***	12,161.31***	16,513.07**	13,839.75***
	median	16,236.04	14,570.05	16,669.83	16,111.53	13,859.24***	11,270.11***	13,982.64	12,550.57***
Trading Volume	mean	791.31	1,776.19	1,919.46	1,185.17	822.50	1,002.73***	1,356.56***	982.69***
	median	565.12	1,201.53	1,419.72	722.39	764.43***	911.63***	1,166.47**	899.75***
Number of trades	mean	15,829.40	5,066.57	4,304.65	11,637.04	9,208.14***	3,930.18*	3,820.74	5,889.57***
	median	13,481.50	2,495.00	2,951.50	7,943.00	6,630.00***	3,356.00**	3,445.00	4,203.50***
Range	mean	0.2920	0.1716	0.1704	0.2462	0.1505***	0.1182***	0.0987***	0.1277***
	median	0.2688	0.1499	0.1431	0.2268	0.1274***	0.0965***	0.0857***	0.1050***

Table 12 Regression Analysis for Nasdaq-Listed IPOs

The dependent variables, *QSpread*, *ESpread*, and *Bid* (*Ask*) *Depth* denote the time-weighted quoted dollar spread, trade-weighted effective dollar spread, and the total bid (ask) quoted share depth, respectively. Price is the average trade price. Volume is average the trading volume. Range is the difference between the high and low trade prices divided by the midpoint of the bid-ask prices. Underpricing is the offer-to-open returns defined as (open price – offer price)/offer price*100. Post is a binary variable indicating the decimal era (Aprial 9, 2001 – December, 31, 2004). t-statistics are shown in the parentheses. **, and *** represent the 5%, and 1% two-tailed significance level, respectively.

	QSpread		ESpread		Bid Depth		Ask Depth	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Intercept	0.0204	0.0204	0.0227	0.0228	0.9229	0.8475	1.2937	1.2581
	(7.43)***	(7.44)***	(10.27)***	(10.30)***	(2.47)**	(2.29)**	(4.46)***	(4.35)***
Post	0.0023	0.0022	-0.0016	-0.0018	-0.3993	-0.2323	-0.4469	-0.3683
	(5.99)***	(4.72)***	(-5.29)***	(-5.01)***	(-7.71)***	(-3.77)***	(-11.12)***	(-7.66)***
Underpricing	0.0020	0.0020	0.0024	0.0024	-0.1188	-0.1344	-0.1031	-0.1105
	(7.05)***	(7.06)***	(10.40)***	(10.45)***	(-3.03)***	(-3.48)***	(-3.43)***	(-3.67)***
Log(Price)	-0.0063	-0.0064	-0.0057	-0.0058	-0.0571	-0.0193	-0.1154	-0.0976
	(-17.19)***	(-17.06)***	(-19.34)***	(-19.28)***	(-1.13)	(-0.38)	(-2.96)***	(-2.48)**
Log(Volume)	0.0004	0.0004	-0.00004	-0.00003	0.2785	0.2749	0.2298	0.2281
	(1.25)	(1.26)	(-0.15)	(-0.13)	(6.70)***	(6.67)***	(7.12)***	(7.09)***
Log(Range)	0.0050	0.0050	0.0082	0.0082	-0.2397	-0.2541	-0.2561	-0.2629
	(3.89)***	(3.90)***	(7.90)***	(7.92)***	(-1.37)	(-1.47)	(-1.89)*	(-1.95)*
Post * Underpricing		0.0012		0.0022		-1.6804		-0.7916
		(0.48)		(1.09)		(-4.90)***		(-2.96)***
F-statistics	105.77***	88.13***	100.64***	84.08***	56.69***	52.16***	92.68***	79.20***
Adj. R^2	0.306	0.306	0.296	0.296	0.190	0.205	0.278	0.283

Chart A

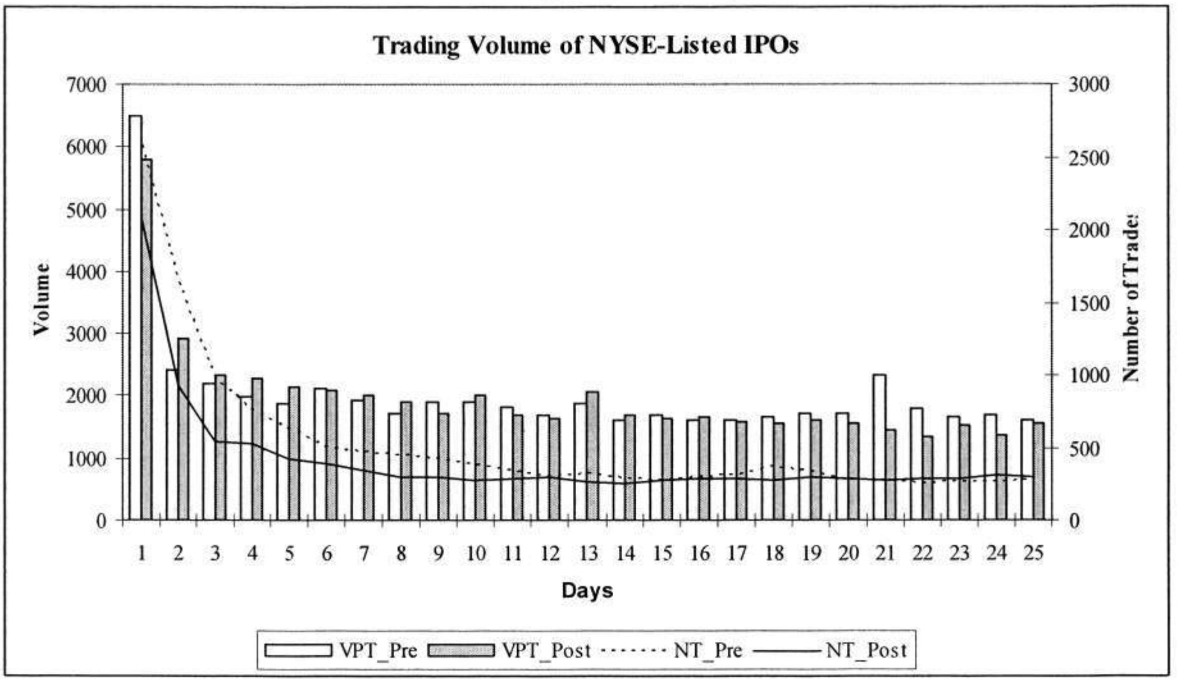

Chart B

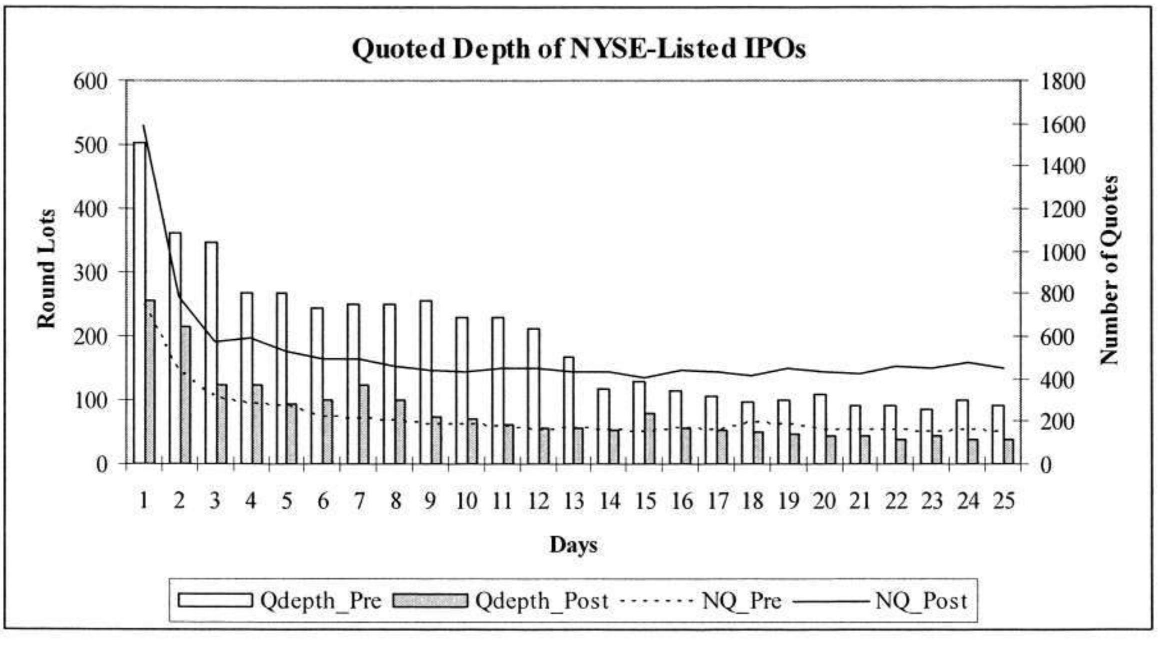

Figure 1. This figure plots the average volume per trade (Chart A) and the average depth per quote (Chart B) of the 230 NYSE-listed IPOs for 25-day in pre- and post-decimalization periods. The VPT_Pre (Qdepth_Pre) and VPT_Post (Qdepth_Post) are average volume per trade (quoted depth per quote), respectively, in pre- and post-decimalizations periods. NT_Pre (NQ_Pre) and NT_Post (NQ_Post) are the average number of total trades (quotes) in pre- and post-decimalization periods, respectively. IPOs issued after January 29, 2001 are classified in post-decimalization period.

Chart A: Number of trades at bid prices – Pre-decimalization

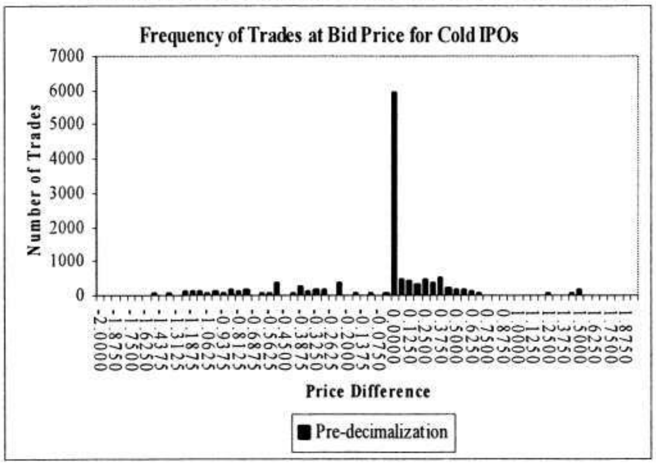

Chart B: Number of trades at bid prices – Post-decimalization

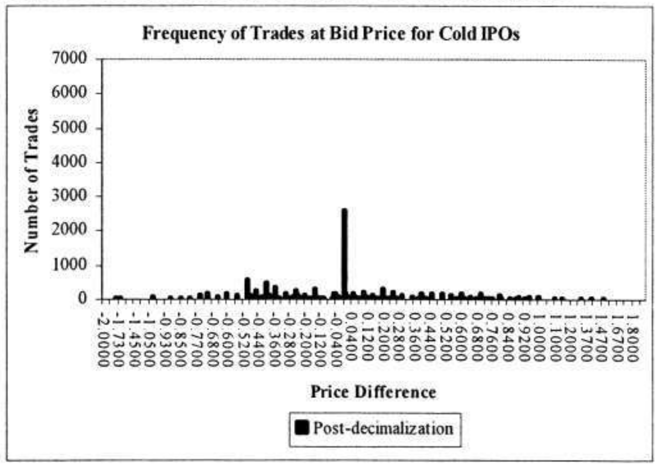

Chart C: Trading volume at bid prices – Pre-decimalization

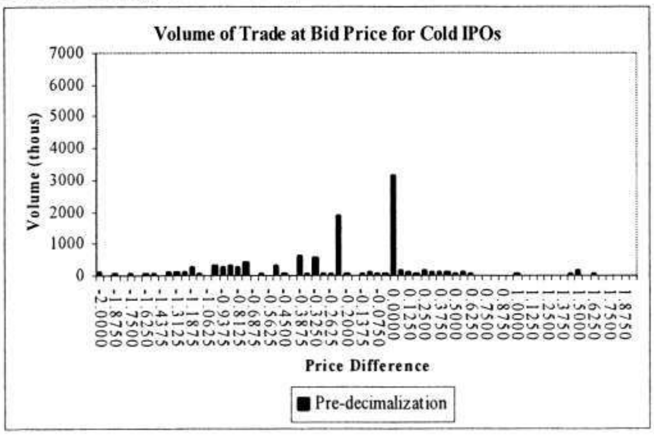

Chart D: Trading volume at bid prices – Post-decimalization

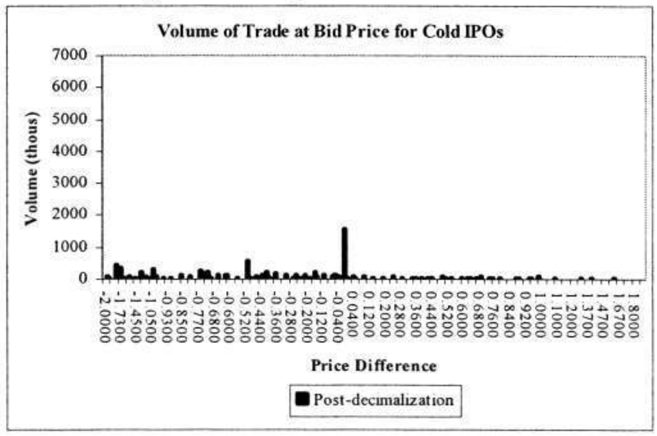

Chart E: Limit buy order execution – Pre-decimalization

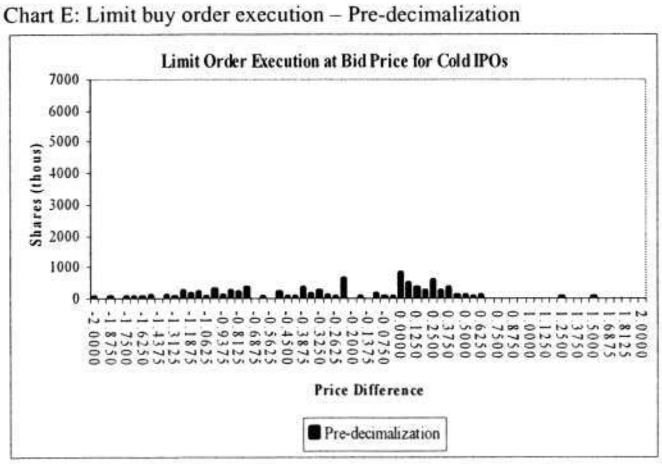

Chart F: Limit buy order execution – Post-decimalization

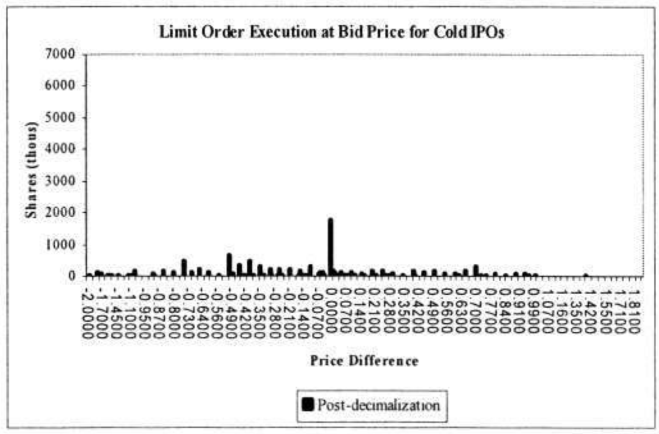

Figure 2. Frequency of trades at bid prices, trading volume at bid prices, and limit buy order execution at bid prices in pre- and post-decimalization for cold IPOs. The figures plot the number of trades, total volume, and limit buy order execution at bids relative to the offering prices of cold IPOs in pre- and post-decimalization. Limit buy order is identified using Greene (1997)'s methodology. IPOs issued after January 29, 2001 are classified in post-decimalization period.

Essay 2

Decimalization and Quote Revisions of the IPO Aftermarket: Evidence on the NYSE

Decimalization and Quote Revisions of the IPO Aftermarket: Evidence on the NYSE

Abstract

We investigate the effect of decimalization on quote revision (both depth and spread) behavior of NYSE-listed IPO stocks. We find that specialists revise their quoted depth more frequently than quoted spread in both the pre- and post-decimalization periods. The proportion of spread revisions among cold and warm IPOs, however, increases after decimalization, suggesting that decimalization helps to reduce the binding constraint on spreads of cold and warm IPOs. But there is no change in the proportion of spread revisions in hot IPOs. In the post-decimalization period, the proportion of bid depth increases is higher, which implies that specialists tend to improve their bids with a smaller increment in depth, compared to the pre-decimalization period. We also show that specialists are more likely to revise quotes that result in a change in spread for high-priced, high-volatility, and/or less reputable underwriters IPOs, and to revise quotes that result in a change in depth for IPOs with smaller underpricing and/or higher risk.

Keywords: Decimalization; IPO underpricing; Liquidity providers; Spread; Depth

JEL Classification: G18; G24; G12; G14

Decimalization and Quote Revisions of the IPO Aftermarket: Evidence on the NYSE

I. Introduction

A series of changes were made to the minimum price variation on the New York Stock Exchange (NYSE). On June 24, 1997, the tick size was first reduced from \$1/8 to \$1/16. With the aim of aligning the NYSE with international practices, decreasing transactions costs, and making prices more easily understood by all investors, the NYSE initiated a decimalization program to further reduce the tick size to \$1/100 or one cent, and it was fully implemented on January 29, 2001. In this essay, we examine how decimalization may affect the quote revisions on the NYSE-listed IPOs, how liquidity providers use both the spread and depth as a means to manage liquidity, and how decimalization may affect their quote revision behavior.

Although numerous studies examine the impact of tick size on dealer and/or specialist quotes, they focus mainly on how the tick size changes affect the spreads and depths individually. For example, Bollen and Whaley (1998), Goldstein and Kavajecz (2000), and Van Ness, Van Ness, and Pruitt (2000) investigate the effects of the tick size reduction from \$1/8 to \$1/16 on common stocks. They find that the overall spread and depth decreased after the tick size change. Charkravarty, Harris, and Wood (2001a, 2001b) show that the decimal pricing resulted in narrower quoted and effective spreads, and thinner quoted depths at best bid and ask prices on the New York Stock Exchange (NYSE). Similarly, Bacidore et al. (2001), and NYSE (2001a, 2001b) show that NYSE stocks exhibit smaller spreads and depths after decimalization. Chakravarty, Wood, and Van Ness (2004) also find that the quoted and effective spreads and both the number of trades and trading volume declined significantly on the NYSE after decimalization. Chung, Charoenwong, and Ding (2004) find that the spread and depth are generally reduced after decimalization because of the removal of the binding constraint and the higher probability of front running.

However, Chung and Chuwonganant (2002) analyze the effects of the tick size change from \$1/8 to \$1/16 on quote revisions (spreads and depths) on the NYSE. They discover that the number of quote revisions that involve the changing of the spread increased significantly after the tick size change. Furthermore, they find that the number of quote revisions initiated by changes in the spread is smaller for stocks with lower prices and/or larger volumes. They interpret the result as evidence that the \$1/16 tick size is still a binding constraint on absolute spreads. The authors also provide evidence that decimalization further reduces price rigidity and increases price competition by showing a significant increase in the frequency of spread quote revisions after decimalization.

Similar to Chung and Chuwonganant (2002)'s study, Chung and Zhao (2004) examine the quote revision behavior of Nasdaq market makers. They find that Nasdaq dealers make more frequent revisions in depths (70%) than in spreads (57%), and the extent of liquidity management is greater for stocks of smaller companies, lower-priced stocks, and stocks with larger trade sizes and fewer number of transactions. The authors explain their results by limit order display rule and price discretion. The authors, however, do not examine the effect of tick size on the quote revision behavior of Nasdaq market makers.

Previous studies on the quote revision behavior of the liquidity providers focus only on the well-established seasoned stocks on NYSE and Nasdaq (see, Chung and

Chuwonganant (2002), and Chung and Zhao (2004)). However, the secondary market liquidity is very important for a successful IPO. A liquid market helps to reduce the transaction costs of investors, the market stabilization and market making costs faced by underwriters, and also ensures the issuing firms access to capital market in the future with lower capital costs.[23]

Ellis, Michaely, and O'Hara (2000) find that the lead underwriter is the only active liquidity provider for the IPOs on Nasdaq, and accumulates substantial inventory positions in aftermarket trading (an average 7% of the IPO shares offered), especially when the newly listed security has been traded below the offer price. Corwin, Harris, and Lipson (2004) show that the underwriter always provides stabilization for IPOs with greater selling pressures by submitting orders on the trading floor. The trading floor contributes an average 55% (36%), 57% (27%), and 74% (18%) of quoted bid (ask) depth for hot, warm, and cold IPOs, respectively, on the first trading day. Boehmer and Fishe (2002, 2004) find that the lead underwriter provides substantial liquidity to the market when share price falls below the offer price (cold IPOs), share price volatility increases, or when market liquidity decreases.

Schultz and Zaman (1994) use the intraday data on underwriter quotes in the aftermarket trading of Nasdaq-listed IPOs, and find that the underwriters are at the inside bid much more frequently, and at the inside ask much less often, than other market makers. Their results show that underwriters tend to quote more inside bid for cold IPOs than for hot IPOs, and other market makers, in contrast, tend to quote less inside bid and more inside ask for cold IPOs than for hot IPOs.

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[23] Amihud and Mendelson (1986) and Brennan and Subrahmanyam (1996) provide a detailed discussion on the relation between liquidity and stock returns.

Given the newly listed firms have no prior trading history and publicly available information, the start of aftermarket trading for IPOs is always regarded as a period of high uncertainty and asymmetric information. Corwin, Harris, and Lipson (2004) note that this unique market condition increases the inventory holding costs of specialists and decreases their willingness to take the positions. Therefore, the spread and depth quotes revised by the specialist for NYSE-listed IPOs are most likely to reflect the liquidity provision of underwriter and limit-order traders, although we label the liquidity providers as specialists throughout this essay.[24]

While prior studies add to the understanding of the effects of decimalization on various aspects of market quality (i.e., spread, depth, and volatility) and provide limited evidence of decimalization on quote revisions, they focus mainly on the well-established seasoned stocks. However, there are no studies exploring how the decimalization may affect the quote revisions behavior of the specialist that reflects the underwriter and limit-order traders for the newly listed firms.

Although Chung and Chuwonganant (2002) and Chung and Zhao (2004) examine the quote revisions behavior of the NYSE specialists and Nasdaq market makers, respectively, our study is different from their studies in several significant ways. First, we analyze the quote revisions on the NYSE-listed IPOs, whereas they analyze mainly the seasoned stocks. Second, our main liquidity providers for the IPOs are the underwriter and limit-order traders, whereas the specialists and market makers are broadly classified, respectively, as the liquidity providers for convenience purposes in Chung and Chuwonganant, and Chung and Zhao. Third, we compare the IPOs in pre- and post-

[24] On the first day of IPO trading, the specialist is required to participate as a dealer in order to maintain a fair and orderly market with reasonable price continuity and depth and to minimize the effects of temporary disparity between supply and demand.

decimalization (full implementation period), whereas Chung and Chuwonganant examine a sample of 158 test stocks during the decimal test phases and Chung and Zhao do not examine the effect of decimalization on the quote revisions behavior of Nasdaq dealers. Finally, we are able to examine the effects of offer design and characteristics on quote revisions, in addition to stock characteristics, whereas only the effects of stock characteristics are examined by Chung and Chuwonganant, and Chung and Zhao.

In this study, we provide additional investigation on the impacts of decimalization on the quote revision behavior of the specialist on the listing day of IPOs on NYSE.[25] Our analyses are particularly important to understand how the specialist jointly utilizes spread and depth to manage the aftermarket liquidity of IPOs in pre- and post-decimalization periods, and the relations between the quote revisions and the firm attributes, and issue characteristics of IPOs, i.e., price, volume, volatility, underpricing, and underwriter reputation. Our findings have important implications of decimalization on aftermarket liquidity management of NYSE- and Nasdaq-listed IPOs.

We examine only the NYSE-listed IPOs for the following reasons. First, the IPO listing requirements and market microstructures of NYSE and Nasdaq are different.[26]

[25] The first day trading of IPOs is a period of extremely high trading activity (e.g., Corwin, Harris, and Lipson (2004) and Ellis, Michaely, and O'Hara (2000, 2002)). The price stabilization and flipping are the major activities, especially during this period. Corwin, Harris, and Lipson (2004) find that the limit order use and disposition tends to stabilize by the second or third day of trading.

[26] Corwin and Harris (2001) find that smaller and riskier firms tend to list on Nasdaq to avoid the higher listing fees on the NYSE. For market microstructure, NYSE is an order-driven market where a call auction allows supply and demand to be aggregated prior to the start of trading. However, Nasdaq is a quote-driven market. Dealers can only specify their best quotes, and participants have no idea of supply and demand away from the inside quotes. Thus, the aggregating demand feature of the NYSE's structure suggests that IPOs listed there will have less underpricing and narrower spreads than IPOs that trade on Nasdaq (see Falconieri et al. (2003)). Importantly, the underwriter typically becomes the market maker of Nasdaq-listed IPOs, but NYSE Rule 98 requires an organizational separation between the underwriter and the specialist.

Second, Nasdaq has higher industry clustering in technology firms,[27] and experienced the internet bubble and burst during our sample period from 1999 to 2002.[28] The use of Nasdaq stocks may contaminate the analysis in this study. Third, Chung, Van Ness, and Van Ness (2003) note that the trade and quote (TAQ) database reports only the largest, not the aggregate, depth at the inside market for Nasdaq issues whereas it reports the aggregate depth, specialist depth plus all the limit orders at the quoted price, for NYSE issues. Hence, it is not possible to study the depth quote revisions on Nasdaq with TAQ data.

Using the TAQ data from the NYSE, we analyze the spreads and depths quote revisions for a sample of 114 and 116 NYSE-listed IPOs before and after decimalization during 1998-2004. We stratify our sample into hot, warm and cold IPOs based on their offer-to-open returns.[29] Based on the distributions of offer-to-open returns for our IPO sample in pre- and post-decimalization periods, we define hot, warm, and cold IPOs as those that opening prices are more than 10 percent above the offer price, 10 percent or less above the offer price, and at or below the offer price, respectively.[30] We find that the specialists change depths more frequently than spreads in both the pre- and post-

[27] Using Standard and Poors Global Industry Classification Standard (GICS) industry code at the 10-industry sector level, about 28% of the firms are classified in information technology industry on Nasdaq, whereas only 7% of the firms are information technology on NYSE.

[28] Ritter and Welch (2002) document that the percentage of technology IPOs dropped from 72% (803 IPOs) during internet bubble in 1999–2000 to 29% (80 IPOs) in 2001.

[29] To control for the market conditions, we also compute the market-adjusted offer-to-open return using the market return (NYSE value-weighted return) prior the IPO listing day. We find that the Pearson's and Spearman's correlations between the offer-to-open return and market-adjusted offer-to-open return are higher at 99% and above in both pre- and post-decimalization.

[30] Previous studies normally use the ad hoc cutoff points to classify the hot, warm, and cold IPOs. Schultz and Zaman (1994) and Ellis, Michaely, and O'Hara (2000) classify the IPOs that traded above the offer price as hot IPOs and IPOs that traded at and below their offer price as cold IPOs. Corwin, Harris, and Lipson (2004) classify hot IPOs as those that open more than 15% above the offer price, and cold IPOs as those that open at or below the offer price. Aggarwal and Conroy (2000) split their IPOs based on offer-to-open returns into weak IPOs with offer-to-open return less than or equal to 10%, and hot IPOs with offer-to-open return greater than 20%.

decimalization periods. However, the proportion of spread revisions increases significantly in the post-decimalization period, but the increment is larger and significant only for warm and cold IPOs. This result suggests a reduction in the binding constraint on the spreads of warm and cold IPOs in the post-decimalization period. In the post-decimalization period, the proportion of bid depth increases is higher, which implies that specialists tend to improve their bids with a smaller increment in depth, compared to the pre-decimalization period.[31] Given the higher selling pressure and underwriter price support for less successful IPOs, the proportions of quote revisions on bid depth, bid depth improvement, ask depth, and ask depth improvement[32] are significantly higher for cold IPOs than for hot IPOs. The cross-sectional regression results show that specialists are more likely to revise their spreads for those IPOs with higher share prices, higher volatility, and/or less reputable underwriters, and to revise the quoted depth for IPOs with less underpriced and/or high risk. Consistent with the results of spread quote revisions, the proportion of improvements in quoted spreads[33] is significantly higher only for warm and cold IPOs in the post-decimalization period. The intraday patterns show that the number of quote revisions is, in general, higher during early trading hours in both the pre- and post-decimalization periods. It is also higher for hot and warm IPOs in the post-decimalization than pre-decimalization period.

The remainder of essay 2 is organized as follows. Section 2 describes the sample data and research methodology. Section 3 presents our empirical results concerning the

[31] There is an improvement in bid depth when the bid size at t is larger than at t-1.
[32] There is an improvement in ask depth when the ask size at t is larger than at t-1.
[33] The spread quote improvement is defined as bid/ask price improvement. Bid price improvement is that bid price at t is larger than bid price at t-1, whereas ask price improvement is that ask price at t is smaller than ask price at t-1.

effects of decimalization on quote revisions of IPOs, and discusses the findings. Section 4 summarizes and concludes this essay.

II. Data and Research Methodology

The IPO sample and descriptive statistics

The NYSE-listed IPO data are obtained from the Securities Data Corporation (SDC) New Issue database during 1998–2004. The unit offerings, closed-end funds, ADRs, and REITs are excluded from our sample. This data selection criteria yield a final sample of 230 NYSE-listed IPOs. We obtain the basic information on offer date, offer price, number of shares issued, net proceeds, number of lead and co-lead managers, and underwriter market shares from the SDC database. We also extract the financial information, such as total assets, earnings before interest and taxes (EBIT), returns on assets (ROA), and debt to asset ratio, from Compustat database. All the financial data are based on the most recent fiscal year ending prior to the IPO. If the data are missing in Compustat, we supplement it from their IPO prospectus filed to SEC. The market value defined as first day closing price times the post-IPO share outstanding is obtained from the Center for Research in Securities Prices (CRSP) database. For each IPO, we retrieve the transaction data from the NYSE's TAQ database. The transaction data provide the time, price, and volume for each trade and quote. As Blume and Goldstein (1997) show, quotes that originate from off the NYSE only occasionally better NYSE quotes. Hence, only NYSE quotes are used in this study.

For the TAQ database, we omit the following to minimize the data errors: (1) quotes if either the ask price or bid price is less than or equal to zero; (2) quotes if either the ask size or the bid size is less than or equal to zero; (3) quotes if the bid price is greater than or equal to the ask price; (4) quotes if the bid-ask spread is greater than $5; (5) before-the-open and after-the-close trades and quotes; (6) trades if the price or volume is less than or equal to zero; (7) out-of-sequence trades and quotes.

Table 1 presents the descriptive statistics of the issue, firm, and trading characteristics for the 230 NYSE-listed IPOs. Using January 29, 2001, the full scale implementation of decimal pricing as the cutoff date, 114 and 116 IPOs are grouped into before and after decimalization samples. None of the issue and firm characteristics is significantly different between pre- and post-decimalization.

In Panel A of Table 1, the mean and median of shares offered, net proceeds, offer price, underwriter market shares, and number of lead and co-lead managers are not significantly different before and after decimalization. The means (medians) of offer price are $18.73 ($17.00) and $19.16 ($18.00) in pre- and post decimalization, respectively. The mean and median open-to-close returns in post-decimalization are 1.00% and 0.34%, respectively. This result is consistent with Barry and Jennings (1992) and Schultz and Zaman (1994) who report that the opening price captures almost all the initial returns. Thus, our classification for hot, warm, and cold IPOs using offer-to-open returns in this study is indifferent to offer-to-close returns.

We present the firm characteristics in Panel B of Table 1. The mean values of market value, total assets, EBIT, ROA, and debt to asset ratio are not statistically significant between pre- and post-decimalization. Together, the results of issue and firm characteristics suggest that our analysis of pre- and post-decimalization will not be affected by the IPO specific characteristics in the pre- and post-decimalization period.

The trading characteristics are presented in Panel C of Table 1. The average share price and average trading volume are not significantly different, in terms of mean and median, during the pre- and post-decimalization period, indicating that IPOs in the pre- and post-decimalization period are highly comparable in addition to the similarity of the issue and firm characteristics. The spread, depth, and volatility are significantly smaller in post-decimalization than in the pre-decimalization period. These results are consistent with the findings for seasoned stocks, which exhibit the smaller spread and lower displayed liquidity in the post-decimalization period. The number of trades is only significant and larger for the median, but is insignificant for the mean, post-decimalization. However, the mean and median of the number of quotes are statistically significant and larger in the post-decimalization period, which implies that the specialists tend to quote more in the decimal pricing environment with smaller depth.

[Insert Table 1 here]

Quote Revisions Classification

Following Chung and Chuwonganant (2002) and Chung and Zhao (2004), we examine the quote revisions in spreads and depths between two consecutive quotes. Thus, with this classification, we are able to investigate how the specialists jointly utilize the spreads and depths as a means of liquidity management for NYSE-listed IPOs. On the NYSE, the liquidity is mainly supplied by the underwriter, public limit orders, and the specialist. Unlike Nasdaq IPOs, where the lead underwriter becomes the market maker, the underwriters providing price support must submit trades through floor traders to the specialists. However, previous studies document that the underwriter is the only active liquidity provider for the aftermarket trading of IPOs, especially for the cold IPOs (e.g., Ellis, Michaely, and O'Hara (2000), Corwin, Harris, and Lipson (2004), and Boehmer and Fishe (2004)). The specialists' participation in IPOs is likely to be limited due to the high uncertainty and asymmetric information of the new issues. We therefore label the quotes for NYSE-listed IPOs as the specialists' quotes that reflect the liquidity provision of underwriter and public limit orders.

We classify each pair of consecutive spread quotes into one of three quote revision groups: decrease in spread (–), no change in spread (0), and increase in spread (+). Similarly, we classify every pair of consecutive depth quotes into one of three quote revision groups: decrease in depth (–), no change in depth (0), and increase in depth (+). By following this procedure, we classify each quote change into a quote revision class (QRC hereafter) (S,D), where S (S = –,0,+) represents the quote revision group for the spread and D (D = –,0,+) represents the quote revision group for the depth. For example, if a quote change involves an increase in the spread and a decrease in the depth, we classify the quote change into QRC(+,-). Similarly, if a quote change involves only a decrease in spread, we classify the quote change into QRC(–,0).

III. Empirical Results

Impact of decimalization on the proportion quotes revisions

In this study, we examine the effect of decimalization on the quote revisions involving changes in the spread (depth) of hot, warm, and cold IPOs listed on NYSE. Therefore, for each sub-group of IPOs classified by decimalization is further divided into three sub-samples categorized by their initial returns defined as offer-to-open returns.

Based on our earlier definition of hot, warm and cold IPOs, there are 52 hot, 33 warm, and 29 cold IPOs issued before decimalization and 58 hot, 40 warm, and 28 cold IPOs issued after decimalization. This sub-grouping is necessary since the degree of the market stabilization by underwriters is likely to vary across IPOs.

To compare the QRC in pre- and post-decimalization for hot, warm, and cold IPOs, we first compute the proportion of quote changes in each QRC for each stock and then obtain the mean and median values of this proportion across the hot, warm, and cold IPOs. Panel A of Table 2 shows that the mean (median) of the proportions of quote revision involving changes in spread (SPCH) [i.e., QRCs(–,–), (–,0),(–,+),(+,–),(+,0), and (+,+)] are 33.54% (33.29%) and 44.10% (44.95%), respectively, in the pre- and post-decimalization period, and both the mean and median of SPCH in the post-decimalization period are significantly larger than in the pre-decimalization period at 1% significance level. However, the mean (median) of the proportions of quote revision involving changes in depth (DPCH) [i.e., QRCs(–,–), (–,+),(0,–),(0,+),(+,–), and (+,+)] are 72.24% (76.46%) are 81.31% (84.09%) in pre- and post-decimalization, respectively, and the mean and median are also statistically significant at the 1% level.

Similarly, we find that, in the pre-decimalization period, the mean (median) of the proportion of quote revisions involving changes only in the spread (SPONLY) [i.e., QRCs (–,0) and (+,0)] are 6.59% (4.70%), and the mean (median) of the proportion of quote revisions involving changes only in the depth (DPONLY) [i.e., QRCs (0,–) and (0,+)] are 45.48% (46.06%). In the post-decimalization period, the mean (median) of SPONLY increases significantly to 7.48% (6.33%), and the mean (median) of DPONLY, however, decreases but not significantly to 44.70% (42.79%).

The quote revisions may vary across the IPOs due to the different degrees of underwriter price stabilization in aftermarket trading. The results show that the mean (median) of SPCH for hot, warm, and cold IPOs are 41.45% (40.95%), 29.49% (27.51%), and 22.93% (21.80%), respectively, in the pre-decimalization period, while the mean (median) of DPCH for hot, warm, and cold IPOs are 74.55% (75.69%), 73.07% (78.40%), and 67.05% (75.00%), respectively. In the post-decimalization period, the mean (median) of SPCH for hot, warm, and cold IPOs are 47.07% (47.80%), 42.98% (43.71%), and 40.62% (41.25%), respectively, while the mean (median) of DPCH for hot, warm, and cold IPOs are 78.76% (81.37%), 78.81% (82.19%), and 87.83% (92.89%). We find that the mean and median of SPCH for hot, warm, and cold IPOs are statistically significant and larger, and the SPCH of cold IPOs increases more than that of hot IPOs, in the post-decimalization period. The mean and median of DPCH are also statistically significant for hot, warm, and cold IPOs between pre- and post-decimalization.

The mean (median) of SPONLY for hot, warm, and cold IPOs are 9.29% (8.26%), 4.15% (3.17%), and 3.76% (2.43%), respectively, in the pre-decimalization period, while the mean (median) of DPONLY for hot, warm, and cold IPOs are 42.39% (43.08%), 47.72% (48.13%), and 48.56% (52.24%), respectively. In the post-decimalization period, the mean (median) of SPONLY for hot, warm, and cold IPOs are 8.81% (7.93%), 7.34% (5.29%), and 5.42% (4.71%), respectively, while the mean (median) of DPONLY for hot, warm, and cold IPOs are 40.50% (41.34%), 44.18% (41.86%), and 52.63% (52.38%), respectively. We find that the mean and median of SPONLY increase significantly only for warm and cold IPOs in the post-decimalization period. However, the mean and median of DPONLY generally decrease in the post-decimalization period, but are not statistically significant for all IPOs categories.

[Insert Table 2 here]

Chung and Chuwonganant (2002) note that specialists can revise their quotes without changing spread quotes through parallel shifts in the bid and ask prices. Therefore, to examine this possibility, we analyze how specialists revise their bid and ask prices relative to the bid and ask depths for hot, warm, and cold IPOs. We present the results in panels B and C of Table 2. The mean (median) of the proportion of quote revisions involving changes in the bid price (BPCH) are 19.61% (19.40%) and 22.41% (22.19%), respectively, in pre- and post-decimalization period, and both the mean and median are statistically significant. The mean (median) of BPCH for hot, warm, and cold IPOs are 23.23% (23.33%), 16.50% (15.58%), and 15.38% (12.60%), respectively, in the pre-decimalization period, while their corresponding figures are 24.43% (25.01%), 21.81% (20.93%), and 19.80% (21.74%) in the post-decimalization period. The mean (median) of the proportion of quote revisions involving changes only in bid price (BPONLY) is not statistically significant between pre- and post-decimalization. Consistent with the results of SPCH and SPONLY, the mean and median of BPCH and BPONLY for warm and cold IPOs increase significantly post-decimalization. The BPCH of hot IPOs does not change much and the BPONLY of hot IPOs are relatively smaller. The t-test and Wilcoxon signed ranks test are significant at the 5% level for BPONLY, but are insignificant for BPCH. On the other hand, the mean (median) of the proportion of quote revisions involving changes in ask price (APCH) in pre- and post-decimalization are 20.19% (19.81%) and 26.77% (26.99%) respectively, and significant at the 1% level.

The mean (median) of the proportion of quoted revisions involving changes only in ask price (APONLY) in pre- and post-decimalization are 4.28% (3.01%) and 4.66% (3.85%), respectively, and both the t-test and Wilcoxon signed ranks test are not statistically significant. The proportions of quote revisions involving changes in bid size (BSCH), and bid size only (BSONLY) for warm and cold IPOs are significantly higher post-decimalization. However, the mean (median) of the proportion of quote revisions involving changes only in ask size (ASONLY) are statistically significant and lower post-decimalization for warm and cold IPOs, but insignificant for hot IPOs. The proportion of quote revisions involving changes in ask size (ASCH) does not change significantly for hot, warm, and cold IPOs.

Together, these results indicate that the specialists revise the depth more frequently than the spread during the pre- and post-decimalization periods, and across IPOs, which is consistent with the finding of Chung and Chuwonganant (2002) that minimum price variation is more frequently the binding constraint than minimum quantity variation.[34] However, the use of the spread increases generally and significantly post-decimalization, indicating that the binding constraint on spread becomes smaller. We observe that, in the pre-decimalization period, the proportions of quote revisions involving changes in spread for warm and cold IPOs are an average 29.49% and 22.93%, respectively, which are relatively smaller than that of hot IPOs (41.45%), but they become about the same at an average 44% post-decimalization. This result suggests that the binding constraint on spread is more prominent for warm and cold IPOs than for hot IPOs pre-decimalization. Importantly, we find evidence that the proportion of quote

[34] Before decimalization, minimum price variation is $1/16, and depths are quoted in multiples of 100 shares which is the minimum quantity variation.

revisions involving changes in spread is only significantly higher in the post-decimalization period for warm and cold IPOs, but not for hot IPOs. This result suggests that decimalization only helps to reduce the binding constraint on spreads for warm and cold IPOs, but it does not further benefit the hot IPOs.

Impacts of decimalization on the conditional proportion of quote revisions

Aggarwal and Conroy (2000) find that during the pre-opening period of an IPO, weak IPOs have very few bid improvements and relatively more improvements in the ask quotes, and the reverse pattern emerges for hot IPOs. In this section, we examine the proportion of quote revisions involving changes in spread or depth conditioning on the improvement of bid (ask) price or depth in aftermarket trading.[35] In Panel A of Table 3, we present the results for the proportion of quote revisions on spread conditioning on bid (ask) quote improvements in the pre- and post-decimalization periods. The mean (median) of the conditional proportion of quote revisions on spread given bid or ask price improvements are 8.77% (8.15%) or 11.42% (11.31%), respectively, in the pre-decimalization period, while the corresponding figures increase significantly to 11.42% (11.31%) or 13.71% (13.85%), respectively, in the post-decimalization period. This spread quote improvement revisions on bid (ask) price in the post-decimalization period is higher and significant than in the pre-decimalization period. However, the results show that the conditional proportions of spread quote revisions on bid (ask) price improvements for hot, warm and cold IPOs are significantly higher in the post-decimalization period. But, the changes in spread quote improvement of cold IPOs is

[35] Improvement of bid (ask) price is defined as bid (ask) price at t is higher (lower) than bid (ask) price at t-1. And, improvement of bid (ask) depth is defined as bid (ask) depth at t is higher than bid (ask) at t-1.

larger than that of hot IPOs, which is decreasing with the underpricing. These results indicate that specialists tend to improve the bid and ask price by revising the spread quotes for warm and cold IPOs due to the smaller binding constraint in the post-decimalization period.

The proportions of quote revisions that involve changes in depth conditioning on bid (ask) depth improvements are presented in Panel B of Table 3. The result shows that the proportion of depth quote revisions conditioning on the improvement of bid depth is significantly higher for cold IPOs in the post-decimalization period, indicating that the cold IPOs receive more price supports in the post-decimalization period. However, the conditional proportions of depth quote revisions on bid depth improvement for hot and warm IPOs are not statistically significant in the post-decimalization period. Although the proportions of depth quote revision conditioning on the ask depth improvement are not statistically significant for hot, warm, and cold IPOs in the post-decimalization period, their mean and median of the conditional proportions of quote revisions involving changes only in depth given ask price improvements are all significantly smaller at the 1% level. This smaller depth quote improvement revision, especially for hot and warm IPOs, suggests that the specialists face the higher adverse selection cost and front-running probability post-decimalization.

[Insert Table 3 here]

Regression analysis

In this section, we present a cross-sectional regression analysis to examine the relationship between the proportion of quote revisions and decimalization, issue characteristics, and stock attributes of the NYSE-listed IPOs. The independent variables used in the regression models include: (1) decimalization dummy (POST), which equals to 1 if the IPOs issued after January 29, 2001, and zero otherwise; (2) underpricing (UNDERPRC), measured for hot, warm, and cold IPOs, is defined as offer-to-open returns; (3) share price (PRC) is the average trade prices of IPOs on the first listing day; (4) trading volume (VOL) is the average transaction sizes of IPOs on the first listing day; (5) volatility (RANGE) is defined as the difference between the high and low trade prices divided by the midpoint of the bid-ask prices; (6) logarithm of the number of lead and co-lead managers in IPO activity; and (7) underwriter market shares defined for each lead underwriter as the proportion of IPO proceeds raised during the sample period.

We present the regression results for the proportion of spread (depth) quote revisions, the proportion of quote revisions for bid price (depth) or ask price (depth), and the conditional proportion of spread (depth) quote revisions on the improvement of bid price (depth) or ask price (depth) in Panel A, B, and C of Table 4, respectively. In Panel A, the results show that SPCH, SPONLY, and DPCH are significant and positively related to POST, indicating that the proportion of spread (depth) quote revisions generally increase in post-decimalization period. In Panel B, the significant and positive of POST indicates that the specialists tend to revise more bid price, ask price, bid size, and ask size in the post-decimalization period. In Panel C, the results show that the specialists are more willing to revise the spread (depth) by improving the bid price (depth) and ask price (depth) in post-decimalization.

The important variable in our regression models is the interaction term of POST and UNDERPRC (POST*UNDERPRC), which is negative and significantly related to

SPCH and SPONLY, but insignificantly to DPCH and DPONLY. This result suggests that the lower proportion of revisions in quoted spreads during the post-decimalization period is associated with greater underpricing. This confirms our previous results that the binding constraint on the spreads of warm and cold IPOs is reduced after decimalization. In sum, we interpret the results reported here as evidence that the cost of revising spread is higher than that of revising depth for less underpriced IPOs because of their higher binding constraint on the spreads.

[Insert Table 4 here]

In addition, the underwriter's market shares (UW_MKTSHR) proxy for their reputation in IPO activity is found significant and negatively related to spread quote revisions (i.e., SPCH, SPONLY, BPCH, APCH, SPCH(BP_t>BP_{t-1} and SPCH(AP_t<AP_{t-1})). Therefore, we argue that if the reputation of an underwriter is high, the role of specialists in liquidity management is smaller as the binding constraint of spread is more severe than that of depth.

The results show that the share price (PRC) is only significant and positively related to the proportion of the spread quote revisions [i.e., SPCH, SPONLY, BPCH, APCH, SPCH(BP_t>BP_{t-1}), and SPCH(AP_t<AP_{t-1})], which is consistent with Chung and Chuwonganant (2002) that specialists are more likely to revise spread quotes for the high-priced stocks, and we find that it is also true for the newly listed securities. The return volatility (RANGE) is significant and positive in all our models, suggesting that the higher the volatility the higher the proportion of spread (depth) quote revisions. However, the trade size (VOL) is not statistically significant for the proportion of spread (depth) quote revisions.

Intraday variation of quote revisions

Chung and Chuwonganant (2004), and Chung and Zhao (2004) document that the intraday variation in the number of quote revisions follows a U-shaped pattern, which is likely driven by the corresponding intraday pattern in trading volume (e.g., Foster and Viswanathan (1993), and Chan, Chung, and Johnson (1995)). In this section, we examine the intraday patterns of quote revisions for hot, warm, and cold IPOs in the pre- and post-decimalization period. We split the day into 30-minute intervals from 09:30 to 16:00 and compute the number of quote revisions during each interval. Figure 1 plots the intraday patterns of the number of quote revisions for all hot, warm, and cold IPOs.

Chart A of Figure 1 plots the intraday variation in the number of quote revisions for all IPOs. The number of quote revisions is higher at the start of trading in the pre- and post-decimalization period. However, the number of quote revisions at the start and close in the post-decimalization period is higher than in the pre-decimalization period. In addition, the number of quote revisions post-decimalization exhibits a stronger U-shaped intraday pattern than in the pre-decimalization period.

Chart B shows that, in the pre-decimalization period, the number of quote revisions for hot IPOs increases till midday, and maintains the same level throughout the rest of the day. In the post-decimalization period, the number of quote revisions exhibits a U-shaped pattern, which is higher in the early trading and last hour of trading but lower during midday. The number of quote revisions is higher in the post-decimalization period than in the pre-decimalization period throughout the day.

In Chart C, the number of quote revisions for warm IPOs is higher post-decimalization than in the pre-decimalization period throughout the whole day. The numbers of quotes in the pre- and post-decimalization periods are higher at the start, and decrease gradually during the day. The number of quote revisions shows a slightly increase in late trading in the post-decimalization period, compared to the pre-decimalization period.

Chart D indicates that the number of quote revisions for cold IPOs is higher in the early trading, lower at midday, and is slightly higher again in the later hours of trading in the pre- and post-decimalization period. The intraday variation of the number of quote revisions is similar pre- and post-decimalization.

[Insert Figure 1 here]

IV. Sensitivity Analysis

NASDAQ-Listed IPOs

In this section, we examine the effect of decimalization on the spread and depth revisions of NASDAQ-listed IPOs. We extract the NASDAQ-listed IPOs from SDC new issue database during 1998–2004. The final sample is 1189 IPOs. NASDAQ converted all the stocks into decimal pricing on April 9, 2001.

We present the regression results in Table 5. The results show that the proportion of spread (depth) revisions increases (decreases) significantly after decimalization. This result suggests that the liquidity providers[36] tend to revise more spread quotes post-decimalization. We find a positive and significant relation between *Underpricing* and

[36] The underwriters are the market makers for Nasdaq-listed IPOs in aftermarket trading. Thus, the main liquidity providers here are mainly the underwriters.

SPCH, suggesting that the liquidity providers tend to revise more spread quotes for more underpriced IPOs than less underpriced IPOs. However, the negative and significant relation between *Underpricing* and *DPCH* provides evidence that underwriters support cold IPOs by revising the depth quotes. Contrary to NYSE-listed IPOs, we do not find that the spread quotes revisions increases for the less underpriced IPOs (i.e., warm and cold IPOs) after decimalization. Interestingly, we find a negative and significant interaction term between *POST* and *Underpricing* for *DPCH*, suggesting that the more underpriced IPOs, the smaller depth quote revisions post-decimalization.

V. Summary and Conclusion

In this essay, we analyze the quote revisions behavior of the specialists that reflects the liquidity management of underwriter and public limit orders for NYSE-listed IPOs on the listing day during the pre- and post-decimalization periods. We find that specialists revise depth quotes more frequently than spread quotes in both the pre- and post-decimalization periods. However, the proportion of quote revisions that involve changes in the spreads of IPO stocks increases significantly in the post-decimalization period. Our result shows that the revisions of quoted spreads of warm and cold IPOs are significant and higher as compared to hot IPOs during the post-decimalization period, suggesting that the binding constraint on warm and cold IPOs is smaller after decimalization. In the post-decimalization period, the proportion of bid depth increases is higher, which implies that specialists tend to improve their bids with a smaller increment in depth, compared to the pre-decimalization period. However, the proportion of ask depth increases is not significantly different between the pre- and post-decimalization periods. This result is not surprising as the limit sell orders submission rate is relatively low at the start of trading for IPOs (see Corwin, Harris, and Lipson (2004)).

We also find that both the bid ($BP_{i,t}>BP_{i,t-1}$) and ask ($AP_{i,t}<AP_{i,t-1}$) price improvements in the quoted spreads occur more post-decimalization and primarily more for warm and cold IPOs. On the other hand, the proportion of quote revisions involving changes in bid depth, bid depth improvement ($BS_{i,t}>BS_{i,t-1}$), ask depth, and ask depth improvement ($AS_{i,t}>AS_{i,t-1}$) are significantly higher for cold IPOs than hot IPOs, suggesting that the selling pressure and underwriter price support are stronger in less successful IPOs.

The cross-sectional regression results for the quote revisions of NYSE-listed IPOs indicate that stock price has a positively significant impact on the revision of quoted spreads but no effect on quoted depth. Trading volume has no effect on both spread and depth quote revisions. Volatility is found to be positive and significant for both spread and depth revisions. The results also show that underwriter reputation is significantly negative for spread revisions. The underpricing of IPOs has no impact on changes in quoted spreads but is negatively related to changes in quoted depths. Overall, the results suggest that specialists are more likely to revise quoted spreads for IPO stocks that are highly-priced, have high-volatility and less reputable underwriters, and to revise quoted depth for those that are less underpriced and have a higher risk.

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Table 1 Summary statistics for sample

This table presents the descriptive statistics for the 230 NYSE-listed IPOs from 1998 to 2004. We report the offer, firm, and trading characteristics for pre- and post-decimalization in Panel A, B, and C, respectively. Net proceeds is the total amount excluding fees and expenses raised by issuers. Offer (Open) to open (close) returns is the difference between the opening (closing) price and offer (opening) price as the percent of the offer (opening) price. Underwriter market share is defined for each lead underwriter as the proportion of IPO proceeds raised during the sample period. The number of underwriters includes lead and co-lead manager in the IPO activity. Market value is defined as post-IPO shares outstanding times the first day closing stock price. The debt to asset ratio equals total debt divided by total assets. Total assets, earnings before interests and taxes (EBIT), returns on assets (ROA), and debt to asset ratio are based on the most recent fiscal year ending prior to the IPO. Share price is the closing price on IPO listing day. Trade size is the average trading volume. Spread is defined as the difference between bid and ask price. Depth is the bid plus ask size. Return volatility is the standard deviation of the intraday returns. For the comparison of the pre- and post-decimalization means and medians, we report the t-statistics and the z-statistics based on Wilcoxon signed ranks test in the parentheses. * and ** represent the 10% and 5% two-tailed significance level, respectively.

	Pre-decimalization (N=114)			Post-decimalization (N=116)			Differences (Post-Pre)	
	Mean	Median	Standard deviation	Mean	Median	Standard deviation	Mean	Median
Panel A Issue characteristics								
Shares Offered ($M)	26.38	11.05	44.55	31.01	14.00	67.20	4.63 (0.62)	2.95* (1.87)
Net Proceeds ($M)	509.04	144.86	1,060.38	532.99	212.52	939.99	23.95 (0.18)	67.66*** (2.79)
Offer Price	18.73	17.00	9.97	19.16	18.00	7.47	0.43 (0.37)	1.00 (1.22)
Offer to Open Returns (%)	14.00	8.21	21.53	9.55	7.23	12.16	-4.45* (-1.93)	-0.98 (0.87)
Open to Close Returns (%)	0.52	0.00	5.64	1.00	0.34	4.89	0.48 (0.68)	0.34 (0.81)
UW Market Share (%)	8.76	9.60	5.87	9.71	9.26	4.63	0.95 (1.36)	-0.34 (-0.88)
No. of Underwriters	5.02	4.00	3.15	6.39	5.00	3.59	1.37*** (3.08)	1.00*** (4.23)
Panel B Firm characteristics								
Market Value ($M)	2,550.66	684.80	5,752.83	2,070.05	973.49	3,451.42	-480.61 (-0.77)	288.69** (2.03)
Total Assets ($M)	8,469.25	535.20	33,626.25	7,508.45	774.98	30,703.04	-960.80 (-0.23)	239.78** (1.96)
EBIT ($M)	128.51	27.00	441.08	91.91	48.35	215.37	-36.60 (-0.78)	21.35 (1.31)
ROA	2.56	2.08	22.00	7.35	2.69	33.78	4.79 (1.24)	0.61 (0.02)
Debt to Asset Ratio	36.93	31.55	32.30	39.40	37.64	35.90	2.47 (0.54)	6.09 (0.32)
Panel C Trading characteristics								
Share Price	21.73	19.00	13.81	21.36	20.05	8.85	-0.37 (-0.25)	1.05 (0.78)
Trade Size (round lots)	65.00	58.12	40.04	57.86	47.71	40.25	-7.14 (1.35)	-10.41 (-1.59)
Spread	0.1368	0.1142	0.0789	0.0664	0.0635	0.0270	-0.0704*** (-9.49)	-0.0507*** (-10.37)
Depth (round lots)	525.33	345.71	588.97	325.17	217.18	495.36	-200.16*** (-3.03)	-128.53*** (-4.81)
Returns Volatility	0.0033	0.0026	0.0024	0.0016	0.0015	0.0007	-0.0017*** (-6.84)	-0.0011*** (-9.53)
Num of Trade	2,583.42	979.00	5,723.68	2,080.08	1,639.00	2,235.29	-503.34 (-0.88)	660.00*** (3.97)
Num of Quote	776.43	622.00	615.24	1,695.85	1,546.00	1,016.59	919.42*** (8.32)	924.00*** (8.33)

Table 2 Proportion of quote revisions involving changes in the spread, depth, bid price, bid size, ask price, and ask size.

This table presents the mean and median values of the proportion of quote revisions for pre- and post-decimalization. SPCH is the proportion of quote revisions involving changes in the spread. DPCH is the proportion of quote revisions involving changes in the depth. SPONLY is the proportion of quote revisions involving changes only in the spread. DPONLY is the proportion of quote revisions involving changes only in the depth. BPCH (APCH) is the proportion of quote revisions involving changes in the bid (ask) price. BSCH (ASCH) is the proportion of quote revisions involving changes in the bid (ask) size. BPONLY (APONLY) is the proportion of quote revisions involving changes only in the bid (ask) price. BSONLY (ASONLY) is the proportion of quote revisions involving changes only in the bid (ask) size. *, **, and *** represent 10%, 5%, and 1% significant level, respectively.

		Pre-decimalization				Post-decimalization			
		Hot	Warm	Cold	All	Hot	Warm	Cold	All
Panel A Spread-depth revisions									
SPCH	Mean	41.45	29.49	22.93	33.54	47.07***	42.98***	40.62***	44.10***
	Median	40.95	27.51	21.80	33.29	47.80***	43.71***	41.25***	44.95***
SPONLY	Mean	9.29	4.15	3.76	6.59	8.81	7.34***	5.42*	7.48
	Median	8.26	3.17	2.43	4.70	7.93	5.29***	4.71**	6.33***
DPCH	Mean	74.55	73.07	67.05	72.24	78.76*	79.81**	87.83***	81.31***
	Median	75.69	78.40	75.00	76.46	81.37***	82.19*	92.89**	84.09***
DPONLY	Mean	42.39	47.72	48.56	45.48	40.50	44.18	52.63	44.70
	Median	43.08	48.13	52.24	46.06	41.34	41.86	52.38	42.79
Panel B Bid price-bid depth revisions									
BPCH	Mean	23.23	16.50	15.38	19.61	24.43	21.81***	19.80*	22.41***
	Median	23.33	15.58	12.60	19.40	25.01	20.93***	21.74***	22.19***
BPONLY	Mean	8.02	3.03	2.50	5.36	5.59**	5.44**	4.99**	5.44
	Median	8.56	2.14	2.05	4.51	5.95**	3.91***	4.33**	5.16
BSCH	Mean	38.95	34.82	26.35	34.66	41.13	39.53**	43.11***	41.05
	Median	39.61	34.43	29.09	36.61	41.47	38.68**	42.53***	41.25
BSONLY	Mean	21.90	21.16	16.80	20.43	21.83	22.27	26.39***	23.08***
	Median	21.86	21.10	16.34	20.04	21.82	21.81	23.86***	22.13**
Panel C Ask price-ask depth revisions									
APCH	Mean	25.33	17.51	13.40	20.19	28.15**	26.10***	25.37***	26.77***
	Median	24.72	17.12	12.78	19.81	28.89**	26.52***	25.92***	26.99***
APONLY	Mean	6.05	2.42	2.47	4.28	5.57	4.34**	3.54*	4.66
	Median	4.99	1.53	1.75	3.01	4.74	3.23***	2.95**	3.85
ASCH	Mean	43.73	45.10	45.28	44.51	45.58	47.67	51.53*	47.74**
	Median	45.22	47.70	51.05	46.65	46.14	48.32	50.81	48.32**
ASONLY	Mean	24.45	30.01	35.56	28.79	23.00	25.92**	29.71*	25.62***
	Median	24.48	28.70	38.32	26.94	23.32	25.75**	27.55**	24.83**

Table 3 The conditional proportion of quote revisions involving changes in the spread and depth

This table shows the mean and median values of the conditional proportion of quote revisions for pre- and post-decimalization. $SPCH(BP_t>BP_{t-1})$ is the proportion of quote revisions involving changes in the spread conditional on the bid price at t is greater than bid price at t-1. $SPCH(AP_t<AP_{t-1})$ is the proportion of quote revisions involving changes in the spread conditional on the ask price at t is smaller than ask price at t-1. $SPONLY(BP_t>BP_{t-1})$ is the proportion of quote revisions involving changes only in the spread conditional on the bid price at t is greater than bid price at t-1. $SPONLY(AP_t<AP_{t-1})$ is the proportion of quote revisions involving changes only in the spread conditional on the ask price at t is smaller than ask price at t-1. $DPCH(BS_t>BS_{t-1})$ is the proportion of quote revisions involving changes in the depth conditional on the bid size at t is greater than t-1. $DPCH(AS_t>AS_{t-1})$ is the proportion of quote revisions involving changes in the depth conditional on the ask size at t is greater than t-1. $DPONLY(BS_t>BS_{t-1})$ is the proportion of quote revisions involving changes only in the depth conditional on the bid size at t is greater than t-1. $DPONLY(AS_t>AS_{t-1})$ is the proportion of quote revisions involving changes only in the depth conditional on the ask size at t is greater than t-1. t test and Wilcoxon signed ranks test are employed to test for the differences in mean and median, respectively, between pre- and post-decimalization. *, **, and *** represent the 10%, 5%, and 1% two-tailed significance level, respectively.

		Pre-decimalization				Post-decimalization			
		Hot	Warm	Cold	All	Hot	Warm	Cold	All
Panel A Spread revisions conditional on bid or ask price improvement									
$SPCH(BP_t>BP_{t-1})$	Mean	10.39	7.13	7.25	8.77	12.53***	10.86***	10.32**	11.42***
	Median	10.82	6.91	5.67	8.15	12.56***	10.65***	10.53***	11.31***
$SPONLY(BP_t>BP_{t-1})$	Mean	1.88	0.98	1.49	1.55	1.76	1.54**	1.01	1.50
	Median	1.52	0.72	0.70	1.15	1.57	1.10***	0.87	1.27
$SPCH(AP_t<AP_{t-1})$	Mean	11.77	8.23	6.40	9.46	14.42***	13.41***	12.94***	13.71***
	Median	11.70	7.72	6.25	9.46	14.52***	13.68***	13.15***	13.85***
$SPONLY(AP_t<AP_{t-1})$	Mean	1.97	0.84	1.06	1.49	1.99	1.58***	1.36	1.70
	Median	1.57	0.53	0.93	1.02	1.71	1.27***	1.01	1.26**
Panel B Depth revisions conditional on bid or ask size improvement									
$DPCH(BS_t>BS_{t-1})$	Mean	17.15	15.80	11.08	15.27	17.72	16.74	18.04***	17.46***
	Median	17.48	16.25	12.68	16.43	18.11	16.23	18.54***	17.70***
$DPONLY(BS_t>BS_{t-1})$	Mean	8.97	9.44	6.99	8.64	7.18***	7.76***	9.21**	7.87*
	Median	9.16	9.10	7.69	8.87	6.55***	7.41***	9.01**	7.91**
$DPCH(AS_t>AS_{t-1})$	Mean	21.76	23.13	22.52	22.34	21.89	22.76	24.00	22.70
	Median	22.09	23.39	22.47	22.41	21.79	22.51	24.47	22.47
$DPONLY(AS_t>AS_{t-1})$	Mean	12.80	16.55	18.07	15.18	9.94***	11.64***	12.72***	11.20***
	Median	12.54	15.98	18.71	14.57	9.80***	11.07***	12.26***	10.87***

Table 4 Regression Analysis

This table presents the regression results of the proportion of quote revisions for 230 NYSE-listed IPOs. The dependent variables are the proportion of quote revisions involving spread, depth, bid price (depth), and ask price (depth). POST is the dummy variable indicating the decimal period (January 29, 2001 – December 31, 2002). UNDERPRC is the underpricing of IPOs defined as offer-to-open returns. PRC is the average trade price. VOL is the average trading volume. RANGE is the difference between the high and low traded prices divided by the midpoint of bid-ask prices. NUM_UW is the number of lead and co-lead managers. UW_MKTSHR is the market shares of underwriter. *, **, and *** represent the 10%, 5%, and 1% significant level, respectively.

Panel A Regression results for the proportion of spread-depth revisions

	SPCH		SPONLY		DPCH		DPONLY	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Intercept	4.0627***	4.0159***	0.2097	0.0782	4.8389***	4.7068***	4.0062***	3.9371***
POST	0.5200***	0.5354***	0.6941***	0.7252***	0.2033***	0.2443***	0.0789	0.1017
UNDERPRC	-0.0623	-0.1235	0.7452**	0.5771*	-0.2866	-0.3108	-0.1900	-0.1682
PRC	0.3136***	0.3607***	0.6216***	0.7475***	0.0157	0.0735	-0.1281	-0.1136
VOL	-0.0418	-0.0387	0.1083	0.1138	0.0018	0.0168	0.0520	0.0614
RANGE	0.4470***	0.4493***	0.6027***	0.5959***	0.2236***	0.2236***	0.1080***	0.1070***
POST*UNDERPRC	-0.9445***	-0.9951***	-1.4459**	-1.5578***	-0.4347	-0.5207	-0.4189	-0.4549
NUM_UW		-0.0150		-0.0107		-0.1296**		-0.0950
UW_MKTSHR		-0.0094*		-0.0306***		0.0030		0.0090
Adj-R^2	0.5516	0.5556	0.4203	0.4463	0.1710	0.1800	0.0397	0.0454
F-statistic	47.33***	36.32***	27.71***	23.27***	8.84***	7.26***	2.57**	2.35**

Panel B Regression results for the proportion of bid price-bid depth and ask price-ask depth revisions

	BPCH		APCH		BSCH		ASCH	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Intercept	2.7064***	2.5434***	3.4563***	3.4056***	4.4482***	4.4483***	4.3589***	4.2204***
POST	0.3142***	0.3438***	0.5042***	0.5214***	0.3240***	0.3255***	0.1378**	0.1797***
UNDERPRC	0.0800	-0.0057	-0.0025	-0.0893	-0.3051	-0.2570	-0.4234**	-0.4777**
PRC	0.3356***	0.4231***	0.2462***	0.3076***	0.1586*	0.1350	0.0046	0.0784
VOL	-0.0027	0.0096	-0.0235	-0.0213	-0.0410	-0.0382	-0.0082	0.0062
RANGE	0.3063***	0.2937***	0.3952***	0.3981***	0.3828***	0.3833***	0.1801***	0.1811***
POST*UNDERPRC	-0.4397	-0.5187*	-0.8807***	-0.9427***	-0.6609*	-0.6482*	-0.2976	-0.3952
NUM_UW		-0.0677		-0.0043		-0.0339		-0.1131*
UW_MKTSHR		-0.0139***		-0.0143***		0.0103*		-0.0031
Adj-R^2	0.4125	0.4479	0.5095	0.5248	0.3495	0.3522	0.0922	0.1020
F-statistic	26.74***	23.31***	40.12***	32.20***	21.32***	16.43***	4.86***	4.24***

Panel C Regression results for the conditional proportion of quote improvements revisions

	SPCH($BP_t>BP_{t-1}$)		SPCH($AP_t<AP_{t-1}$)		DPCH($BS_t>BS_{t-1}$)		DPCH($AS_t>AS_{t-1}$)	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Intercept	2.3280***	2.1713***	2.4732***	2.3682***	3.3968***	3.4045***	3.3780***	3.2316***
POST	0.4714***	0.4956***	0.5731***	0.6079***	0.2878***	0.2859***	0.0797	0.1241*
UNDERPRC	0.0604	-0.0407	0.1256	0.0264	-0.2031	-0.1869	-0.4103*	-0.4663**
PRC	0.3342***	0.4263***	0.2119***	0.2978***	0.1692**	0.1588*	-0.0165	0.0609
VOL	-0.0461	-0.0361	-0.0037	0.0051	-0.0187	-0.0188	0.0254	0.0406
RANGE	0.3304***	0.3144***	0.3396***	0.3444***	0.3803***	0.3803***	0.1581***	0.1590***
POST*UNDERPRC	-0.5591*	-0.6315**	-0.8487***	-0.9486***	-0.7122**	-0.7033**	-0.2439	-0.3468
NUM_UW		-0.0442		-0.0557		-0.0033		-0.1206*
UW_MKTSHR		-0.0185***		-0.0135***		0.0030		-0.0030
Adj-R^2	0.4681	0.5112	0.5154	0.5364	0.3950	0.3904	0.0586	0.0710
F-statistic	33.27***	29.77***	41.07***	33.69***	25.70***	19.17***	3.37***	3.18***

Table 5 Sensitivity Analysis – Nasdaq IPOs

This table presents the regression results of the proportion of spread and depth revisions for 1189 Nasdaq-listed IPOs. The dependent variables are the proportion of quote revisions involving spread and depth. POST is the dummy variable indicating the decimal period (April 9, 2001 – December 31, 2004). UNDERPRC is the underpricing of IPOs defined as offer-to-open returns. PRC is the average trade price. VOL is the average trading volume. RANGE is the difference between the high and low traded prices divided by the midpoint of bid-ask prices. t-statistics are in the parentheses. *, **, and *** represent the 10%, 5%, and 1% significant level, respectively.

	SPCH		DPCH	
	Model 1	Model 2	Model 1	Model 2
Intercept	2.0640 (8.49)***	2.0689 (8.50)***	4.8016 (99.04)***	4.7936 (99.41)***
Post	0.8635 (25.65)***	0.8525 (21.08)***	-0.0391 (-5.82)***	-0.0213 (-2.66)***
Underpricing	0.1553 (6.16)***	0.1563 (6.18)***	-0.0244 (-4.86)***	-0.0261 (-5.20)***
Log(Price)	0.0196 (0.60)	0.0171 (0.52)	-0.0033 (-0.50)	0.0007 (0.11)
Log(Volume)	0.1732 (6.41)***	0.1734 (6.41)***	-0.0406 (-7.53)***	-0.0410 (-7.65)***
Log(Range)	0.5326 (4.69)***	0.5335 (4.70)***	-0.0172 (-0.76)	-0.0187 (-0.83)
Post * Underpricing		0.1108 (0.49)		-0.1785 (-4.00)***
F-statistics	140.95***	117.42***	21.97***	21.21***
Adj. R^2	0.371	0.371	0.081	0.093

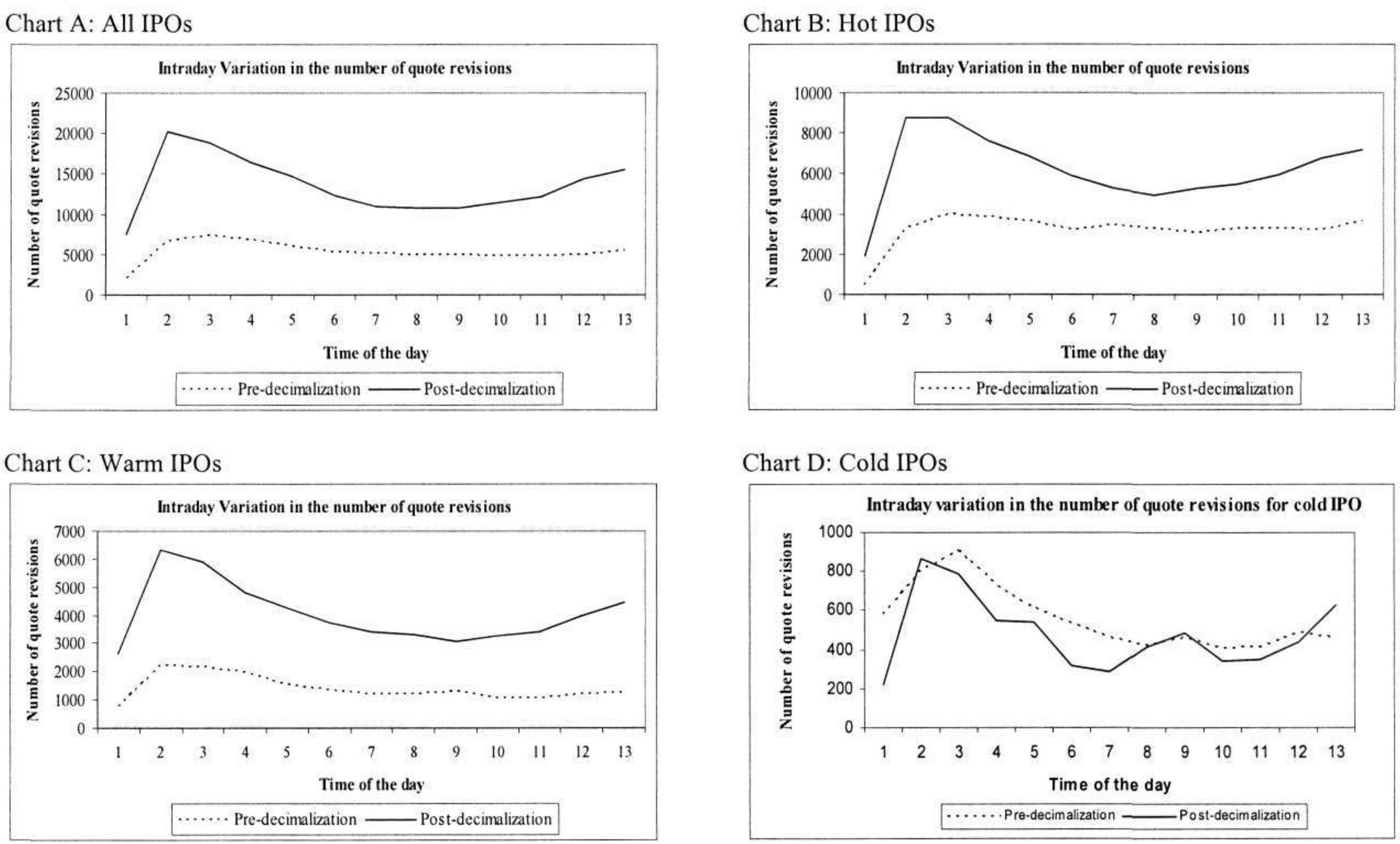

Figure 1. The number of quote revisions for all, hot, warm, and cold IPOs. The number of quote revisions includes the changes in QRCs(–,–), (–,0), (–,+), (0,–), (0,+), (+,0), (+,–), (+,+). The time of the day is divided into 13 successive 30-minute intervals.

Essay 3

Returns, Volatility, and Limit Order Executions: An Examination of Decimalization on NYSE-Listed IPOs

Returns, Volatility, and Limit Order Executions:
An Examination of Decimalization on NYSE-Listed IPOs

Abstract

In this essay, we examine the effects of decimalization on returns, volatility, and limit order executions of the NYSE-listed IPOs. We find that the opening price captures almost all the initial return in pre- and post-decimalization periods. However, the initial and intraday returns of hot IPOs are smaller in post-decimalization period. The results reveal that there is no profit opportunity for day-traders who buy and sell shares of newly listed issues during the first trading day, and the higher front-running probability explains the lower returns of hot IPOs in post-decimalization period. The volatility is higher at the start of trading, suggesting the information-driven trade is greater during this period, and it stabilizes throughout the rest of the day. The intraday volatility is significantly lower for hot and warm IPOs, especially at the start of trading, throughout the day in post-decimalization period, suggesting that the information flows changed after decimalization. The proportion of limit order executions is lower after decimalization due to the lower displayed liquidity and the lower cost of submitting market orders. The proportion of limit order executions at the start of trading is higher in pre- and post-decimalization, and stabilizes quickly. In post-decimalization, the proportions of limit order executions for hot and warm IPOs are lower at the start of trading, but cold IPOs do not exhibit the same. These results suggest that the execution rate of limit orders depends on underpricing.

Keywords: Decimalization; IPO underpricing; Return; Volatility; Limit Order Execution
JEL Classification: G18; G24; G14

Returns, Volatility, and Limit Order Executions: An Examination of Decimalization on NYSE-Listed IPOs

I. Introduction

On January 29, 2001, the New York Stock Exchange (NYSE) fully moved from fractional pricing to decimal pricing.[37] The changes in tick size have attracted a pool of researchers to analyze its impacts on various aspects of market quality. However, the research and discussion in decimalization policy are still growing and debating. Charkravarty, Harris, and Wood (2001a, 2001b) show that the decimal pricing resulted in narrower quoted and effective spreads, and thinner quoted depths at best bid and ask prices on the NYSE. Similarly, Bacidore et al. (2001), and NYSE (2001a, 2001b) show that NYSE stocks exhibit smaller spreads and depths after decimalization. Chakravarty, Wood and Van Ness (2004) also find that the quoted and effective spreads and both the number of trades and trading volume declined significantly on the NYSE after decimalization. Bacidore, Battalio, and Jennings (2003) find that the traders do not reduce the use of limit orders in favor of market orders, but the size of limit order is smaller and the cancellation rate is higher after decimalization. On the other hand, Jones and Lipson (2001) find that the institutional trading costs increased significantly following the move of tick size from eights to sixteenths, whereas Werner (2003) shows that there is no evidence that the execution quality of institutional orders deteriorated following decimalization. Using mutual funds data, Bollen and Busse (2003) show that the trading costs for mutual funds increased as a result of decimalization.

[37] NYSE first lowered the minimum tick size of seven securities to penny on August 28, 2000, 57 securities more on September 25, 2000, and an additional 94 securities on December 5, 2000.

Since the decimalization implemented on NYSE has the important implications for its market microstructure, the previous studies focus mainly on the well-established seasoned stocks. However, there are no studies exploring how the decimalization may affect the market quality and trading behavior of the newly listed firms. We expect that the decimalization may affect the trading behavior of the newly listed securities in the aftermarket trading.

The underpricing of initial public offerings (IPOs) is a well-known phenomenon.[38] The underpricing is always determined on the first day of IPOs trading. Barry and Jennings (1992), Schultz and Zaman (1994), and Aggarwal and Conroy (2000) report that almost the entire initial return is captured by the first trade price in the aftermarket trading of IPOs. Cheng, Cheung, and Po (2004) also find the same result for Hong Kong-listed IPOs, and conclude that the Hong Kong stock market is efficient in adjusting for IPO underpricing. In post-decimalization, the price increment of one tick is just \$0.01 as compared to \$0.0625 in pre-decimalization. The smaller tick size is also likely to induce a higher probability of stepping ahead from the sell-side in aftermarket. Therefore, the initial return of IPOs is believed to be smaller after decimalization. Aggarwal and Conroy (2000) find that the initial return is actually determined during the 5-minute preopening period of IPO trading, so we should see that the initial return measured by the first trade price still captures the entire IPO underpricing in pre- and post-decimalization.

The start of trading for IPOs is always regarded as a period of high uncertainty and asymmetric information, implying that the volatility during this period is relatively

[38] See, for example, Ibbotson and Jaffe (1975), Miller and Reilly (1987), Smith (1986), Ritter (1984), and Loughran, Ritter, and Rydqvist (1994). The underpricing is also well documented globally.

higher than other periods in the day. The high trading volume and volatility during the start of trading are likely to be the information-driven trading.[39] Since the information contained in each trade is quite different across IPOs, the volatility is likely dependent on the degree of underpricing. Previous studies document that the reduction in the tick size could lead to reductions in liquidity supply. Bessembinder (2003), therefore, notes that decreased liquidity could be manifest in the form of more volatile prices, but he finds that the intraday volatility declines rather than increases after decimalization on NYSE and Nasdaq. Chakravarty, Wood, and Van Ness (2004) find that the stock return volatilities of seasoned stocks increase initially but decline over the longer term in post-decimalization. Thus, if the smaller tick size leads to the higher (lower) information-contained in IPO trade, the volatility will decline (increase) after decimalization.

Corwin, Harris, and Lipson (2004) show that limit orders provide an important and informative source of liquidity for NYSE-listed IPOs, and find that the limit order submission (cancellation) rates are lower (higher) on the first day of trading. These findings suggest that the traders tend to choose market orders over limit orders on day one of IPO trading. In addition, the sell order execution rates are higher for all IPOs, and the execution rate for buy orders in cold IPOs is unusually high at the start of trading. The low execution rate for buy orders in hot IPOs reflects that the prices rise away rapidly from buy orders on the first day. In post-decimalization, the floor trader can strategically step ahead of standing limit orders by marginally improving on the limit order's price. Limit orders are therefore more likely to execute when conditions are unfavorable and traders will be less willing to submit the large limit orders. With a lower transaction cost,

[39] Information-Driven Trade hypothesis predicts negative correlation between trading volume and subsequent volatility, whereas Liquidity-Driven hypothesis predicts positive correlation between trading volume and subsequent volatility.

traders will find it less costly to submit market orders over limit orders. Together, we believe that the limit order executions rate for IPOs is lower after decimalization, and varies across order types and underpricing.

In this study, we provide an investigation of the impacts of decimalization on the return, volatility, and limit order executions on the listing day of NYSE-listed IPOs.[40] From the intraday patterns, we are able to examine how the decimalization may affect the trading behavior of IPOs on the return, volatility, and limit order executions in the aftermarket. Our analyses in this study add to the understanding of the effects of decimalization on the intraday trading behavior of the newly listed securities in addition to seasoned stocks.

We examine only the NYSE-listed IPOs for the following reasons. First, the IPO listing requirements and market microstructures of NYSE and Nasdaq are different.[41] Second, Nasdaq has higher industry clustering in technology firms,[42] and experienced the internet bubble and burst during our sample period from 1998 to 2004.[43] The use of Nasdaq stocks may contaminate the analysis in this study. Third, Chung, Van Ness, and Van Ness (2003) note that the trade and quote (TAQ) database reports only the largest,

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[40] The first day trading of IPOs is a period of extremely high trading activity (e.g., Corwin, Harris, and Lipson (2004) and Ellis, Michaely, and O'Hara (2000, 2002)). The price stabilization and flipping are the important activities especially during this period. Corwin, Harris, and Lipson (2004) find that the limit order use and disposition tends to stabilized by the second or third day of trading.

[41] Corwin and Harris (2001) find that smaller and riskier firms tend to list on Nasdaq to avoid the higher listing fees on the NYSE. For market microstructure, NYSE is an order-driven market where a call auction allows supply and demand to be aggregated prior to the start of trading. However, Nasdaq is a quote-driven market. Dealers can only specify their best quotes, and participants have no idea of supply and demand away from the inside quotes. Thus, the aggregating demand feature of the NYSE's structure suggests that IPOs listed there will have less underpricing and narrower spreads than IPOs that trade on Nasdaq (see Falconieri et al. (2003)). Importantly, the underwriter typically becomes the market maker of Nasdaq-listed IPOs, but NYSE Rule 98 requires an organizational separation between the underwriter and the specialist.

[42] Using Standard and Poors Global Industry Classification Standard (GICS) industry code at the 10-industry sector level, about 28% of the firms are classified in information technology industry on Nasdaq, whereas only 7% of the firms are Information technology on NYSE.

[43] Ritter and Welch (2002) document that the percentage of technology IPOs dropped from 72 percent (803 IPOs) during internet bubble in 1999 – 2000 to 29 percent (80 IPOs) in 2001.

not the aggregate, depth at the inside market for Nasdaq issues whereas it reports the aggregate depth, specialist depth plus all the limit orders at the quoted price, for NYSE issues. Hence, it is not possible to apply the inferred limit order algorithm developed by Greene's on Nasdaq with TAQ data.

Using the TAQ data from the NYSE, we analyze the spreads and depths quote revisions for a sample of 114 and 116 NYSE-listed IPOs before and after decimalization during 1998-2004. We stratify our sample into hot, warm and cold IPOs based on their offer-to-open returns.[44] Based on the distributions of offer-to-open returns for our IPO sample in pre- and post-decimalization periods, we define hot, warm, and cold IPOs as those that opening prices are more than 10 percent above the offer price, 10 percent or less above the offer price, and at or below the offer price, respectively.[45]

Consistent with the previous studies, we find that almost all the initial return is captured by the opening price. The result also indicates that the day traders are unable to make profit from investing in the newly listed issues in aftermarket trading. From the intraday return variation, we find that the initial return of hot IPOs is lower in post-decimalization period, suggesting that the higher probability of front-running and the lower displayed liquidity affect the trading behavior of the investors in these issues.

[44] To control for the market conditions, we also compute the market-adjusted offer-to-open return using the market return (NYSE value-weighted return) prior the IPO listing day. We find that the Pearson's and Spearman's correlations between the offer-to-open return and market-adjusted offer-to-open return are higher at 99% and above in both pre- and post-decimalization.

[45] Previous studies normally use the ad hoc cutoff points to classify the hot, warm, and cold IPOs. Schultz and Zaman (1994) and Ellies, Michaely, and O'Hara (2000) classify the IPOs that traded above the offer price as hot IPOs and IPOs that traded at and below their offer price as cold IPOs. Corwin, Harris, and Lipson (2004) classify hot IPOs as those that open more than 15% above the offer price, and cold IPOs as those that open at or below the offer price. Aggarwal and Conroy (2000) split their IPOs based on offer-to-open returns into weak IPOs with offer-to-open return less than or equal to 10%, and hot IPOs with offer-to-open return greater than 20%.

The intraday volatility is higher at the start of trading in pre- and post-decimalization period, as the rate of information resolution is high during the early hour of trading. However, the volatilities of hot and warm are lower, especially at the start of trading, throughout the day in post-decimalization, indicating that the higher probability of front-running and adverse selection cost in post-decimalization reduce the incentives of traders to reveal their interests in the newly listed issues, especially for more underpriced IPOs. The intraday volatility pattern of cold IPOs is similar in pre- and post-decimalization. We argue that the information contained in cold IPOs is higher than that of in hot IPOs. Thus, decimalization should not alter the intraday volatility of cold IPOs.

The proportion of limit order executions is lower after decimalization because of the lower displayed liquidity and lower cost of submitting market orders. For the sell orders, the proportion of limit order executions is lower for hot and warm IPOs in post-decimalization, suggesting that the traders are likely to choose market sell orders over limit sell orders when the share prices runup rapidly. The proportion of limit order buy executions, however, does not change much after decimalization. The intraday pattern reveals that the proportion of limit order executions is higher at the start of trading, and stabilizes rapidly in pre- and post-decimalization. In post-decimalization, the proportions of limit order executions are lower at the start of trading for hot and warm IPOs due to the higher non-execution rate.

The remainder of the essay 3 is organized as follows. Section 2 describes the sample data and research methodology. Section 3 presents our empirical results concerning the effects of decimalization on return, volatility and limit order executions of NYSE-listed IPOs, and discusses the findings. Section 4 summarizes and concludes.

II. Data and Research Methodology

Sample and descriptive statistics

The IPO data are obtained from the Securities Data Corporation (SDC) New Issue database during 1998 – 2004. We only select IPOs listed on NYSE. The unit offerings, closed-end funds, ADRs, and REITs are excluded from our sample. This data selection criteria yield a final sample of 230 NYSE-listed IPOs. We obtain the basic information on offer date, offer price, number of shares issued, net proceeds, and filling price range from the SDC database. The shares outstanding and the market value defined as first day closing price times the post-IPO share outstanding is obtained from the Center for Research in Securities Prices (CRSP) database. For each IPO, we retrieve the transaction data from the NYSE's TAQ database. The transaction data provide the time, price, and volume for each trade and quote. As Blume and Goldstein (1997) show, quotes that originate from off the NYSE only occasionally better NYSE quotes. Hence, only NYSE quotes are used in this study.

For the TAQ database, we omit the following to minimize the data errors: (1) quotes if either the ask price or bid price is less than or equal to zero; (2) quotes if either the ask size or the bid size is less than or equal to zero; (3) quotes if the bid price is greater than or equal to the ask price; (4) quotes if the bid-ask spread is greater than $5; (5) before-the-open and after-the-close trades and quotes; (6) trades if the price or volume is less than or equal to zero; (7) out-of-sequence trades and quotes.

Table 1 presents the descriptive statistics of the issue and trading characteristics for the 230 NYSE-listed IPOs. Using January 29, 2001, the full scale implementation of decimal pricing, as the cutoff date, 114 and 116 IPOs are grouped into pre- and post-decimalization samples. None of the issue characteristics is significantly different between pre- and post-decimalization, suggesting that our findings in this study are not driven by the IPO characteristics.

In Panel A of Table 1, the mean values of shares offered, net proceeds, offer price, and market capitalization are not significantly different before and after decimalization. The means (medians) of offer price are \$18.73 (\$17.00) and \$19.16 (\$18.00) in pre- and post decimalization, respectively. The mean (median) open-to-close returns in pre- and post-decimalization are 0.52% (0.00%) and 1.00% (0.34%), respectively. This result is consistent with Barry and Jennings (1992), Schultz and Zaman (1994), and Aggarwal and Conroy (2000) who report that the opening price captures almost all the initial returns. Thus, our classification for hot, warm, and cold IPOs using offer-to-open returns in this study is indifferent to offer-to-close returns.

The trading characteristics are presented in Panel B of Table 1. The average trading volume is not significantly different, in terms of mean and median, in pre- and post-decimalization period, which indicate that the IPOs in pre- and post-decimalization period are highly comparable in additions to the similarity of the issue characteristics. The quoted and effective spreads, dollar and share depths, and volatility are significantly smaller in post-decimalization than in pre-decimalization period. These results are consistent with the findings for seasoned stocks, which exhibit the smaller spread and lower displayed liquidity in the post-decimalization period. The number of trade is only significant and higher for the median, but is insignificant for the mean, in the post-decimalization. However, both mean and median of the number of quote are statistical significant and larger in the post-decimalization, which implies that the liquidity providers tend to quote more in the decimal pricing environment with smaller depth.

[Insert Table 1 here]

Research Methodology

Return

We stratify the intraday into 5-minute increments from 9:30 A.M. to 16:00 A.M. relative to the IPO's first trade. There are 78 five-minute intervals in the trading day, but only the initial return and the first 60 intervals are examined since some IPOs start trading after the market opening.[46] The initial return is measured from the offering price to the first trade price. The return of the five-minute interval is computed as the logarithm of the ratio of the last and the first transaction prices during that interval.

Volatility

In order to avoid the thin trading problem experienced by some new issues during the intraday five-minute intervals, we follow the method proposed by Parkinson (1980) to measure the volatility during the *i*th five-minute interval as bellows.

$$Volatility_i = \log\left(\frac{HP_i}{LP_i}\right)$$

where HP_i and LP_i are the highest and lowest prices during the *i*th five-minute interval respectively.

[46] Schultz and Zaman (1994) examine only the first 30 ten-minute intervals from the total 39 ten-minute intervals in the trading day.

Limit orders execution

Since TAQ data contains only execution data and do not identify what proportion of any executed order is executed against a limit order. However, the NYSE rules require the specialists to update not just the prices but also indicate the depth at posted quotes and this depth reflects limit orders as well as the specialist's own willingness to trade. Following the algorithm proposed by Greene (1997),[47] we use the changes in posted depth to measure the potential limit order executions. More specifically, the limit order algorithm looks at the differences between two successive quotes. If the ask and bid remain the same but the depth on the bid decreases, the algorithm looks for a trade or trades that took place at the bid price after the first quote and before the second quote. It then classifies a portion of the trades equal to the difference in depths as having been executed against limit buy orders. If the bid price of the second quote is lower than that of the first quote, a portion of the intervening trades which were executed at the original bid price is said to have been executed again limit buy orders. A similar classification is applied to the ask side to identify the execution of limit sell orders. (see, Appendix 1 for an example of sequence of quotes and transactions with limit order executions)

III. Empirical Results

Impact of decimalization on return

Table 2 presents the intraday return pattern of 230 NYSE-listed IPOs on their first trading days. The result shows that the opening price captures almost all initial return for hot, warm, and cold IPOs in pre- and post-decimalization.

[47] The limit order algorithm was validated in Greene (1997) using the SuperDot orders. The algorithm correctly identifies limit order executions average over 77%.

In Pane A, the offer-to-open return is 11.66% and 8.50% in pre-decimalization and post-decimalization, respectively. In Panel B, the offer-to-open return of hot IPO in pre-decimalization is 23.85%, compared to 18.24% in post-decimalization. This result also suggests that the liquidity of hot IPOs improves significantly after decimalization resulted in smaller required underpricing.[48] However, the returns of warm and cold IPOs in pre- and post-decimalization period do not differ so much.

[Insert Table 2 here]

In Table2, the intraday return patterns of IPOs in aftermarket trading (interval 1 to 60) do not differ from each other. The variation is only found between the offer-to-open return and the intraday returns. This result indicates that the day traders cannot make any profit from investing in newly listed issues in aftermarket trading. Only the investors who could successfully subscribe for the IPOs can make profit when they sell after the market opens.

The lower intraday return of hot IPOs after decimalization suggests that the higher probability of front-running restricts the return of hot IPOs. Given the lower displayed liquidity due to the smaller tick size, it is costly to consume liquidity at different quotes, so the demand decreases. On the other hand, the cost of flipping is lower for those share prices runup substantially in aftermarket trading.

Impacts of decimalization on volatility

Following Parkinson's procedure to avoid the thin trading problem during the five-minute intervals, we plot the intraday volatility in pre- and post-decimalization

[48] Ellul and Pagano (2002) argue that the less predictable liquidity of IPO shares, the larger will be the required underpricing.

period in Figure 1. The Panel A shows that the intraday volatility is generally lower throughout the day in post-decimalization than in pre-decimalization period. The intraday volatility patterns for hot, warm, and cold IPOs are shown in Panel B, C, and D, respectively. The volatility is higher at the start of trading in pre- and post-decimalization period, suggesting the information-driven trade is greater during the early hours of trading. The Panel B and C show that the volatility is lower throughout the day, especially during the first thirty-minute of trading, and less volatile for hot and warm IPOs in post-decimalization period. However, Panel D shows that the volatility of cold IPOs does not reduce in post-decimalization period, suggesting that the information flow is still the same as in pre-decimalization period.

These overall results suggest that the volatility does not cause the reduction in liquidity of IPOs in post-decimalization period. The decrease in volatility, especially for hot and warm IPOs, in post-decimalization period might reflect changing information flows. In post-decimalization, the higher probability of front-running and adverse selection cost of submitting limit orders may lower the incentives of investors to reveal his or her private information with large size orders.

[Insert Figure 1 here]

Impacts of decimalization on limit order executions

In Table 3, we present the mean and median of the proportion of executed limit orders on day one of trading. The proportions are computed based on the same side of the market orders, i.e., limit order sells (market buys) and limit order buys (market sells) using both share and dollar volume. We observe that the proportions of limit orders sell executions are higher than that of limit orders buy executions for hot and warm IPOs. In contrast, the proportion of limit orders buy executions for cold IPOs is higher than that of limit orders sell executions. In pre-decimalization, the proportions of limit orders sell executions for hot and warm IPOs are higher than that for cold IPOs, but this relationship does not hold after decimalization. However, we also find a negative relation between the proportion of limit orders buy executions and underpricing in pre- and post-decimalization.

Together, these results are consistent with Corwin, Harris, and Lipson (2004) that the prices move away from buy orders rapidly for hot IPOs, and the traders may either reposition their limit orders or change to market orders. The higher proportions of limit orders buy executions of cold IPOs in pre- and post-decimalization are because of the higher selling pressures and underwriter price support in these issues.

In post-decimalization, our results show that the proportion of limit order executions decreases significantly.[49] The means (medians) of the proportions of limit order sells executions for hot IPOs are 18.08% (17.10%) and 10.12% (9.38%), respectively, in pre- and post-decimalization periods, and both t-test and Wilcoxon signed ranks test are significant at 1% level. For cold IPO sell orders, the proportion of limit orders execution does not change much after decimalization. The results also show that the proportions of limit orders buy executions do not reduce significantly for hot, warm, and cold IPOs in post-decimalization. Thus, these results suggest that the displayed liquidity is relatively lower after decimalization, and traders tend to choose market sell orders over limit sell orders for hot and warm IPOs in post-decimalization due to the

[49] Using Greene's inferred limit order executions algorithm, Arnold and Lipson (1997) find that the proportion of limit order executions increases significantly from an average 13 percent to 18 percent for NYSE/AMEX stock splits.

lower costs (smaller tick size) of submitting sell market orders in these issues which share prices runup rapidly at the start of trading.

[Insert Table 3 here]

In Figure 2, we plot the 5-minute intraday variations of the proportions of limit orders executions in pre- and post-decimalization. The intraday is grouped into 5-minute increments from 9:30 A.M. to 16:00 A.M. relative to the IPO's first trade. Since some IPOs start trading after the market opening, we use only the first 40 five-minute intervals for the proportion of limit orders executions.

Figure 2 shows that the proportion of limit orders executions is higher at the start of trading in pre- and post-decimalization periods. This result is consistent with the notion that the execution rate of limit orders is higher during high uncertainty period (see, Hasbrouck and Saar (2002)). However, we find that the proportions of limit orders executions at the start of trading for hot and warm IPOs (Panel B and C) are higher in pre-decimalization than in post-decimalization, but the proportion of limit orders executions for cold IPOs (Panel D) does not reduce as much as hot IPOs. In post-decimalization period, the traders are more likely to submit market orders rather than limit orders for hot and warm IPOs due to the price movement (non-execution risk) and lower transaction costs (smaller tick size). Figure 2 also shows that the proportion of limit orders executions tends to stable after one hour of trading.

[Insert Figure 2 here]

IV. Summary and Conclusion

In this essay, we analyze the intraday patterns of return, volatility, and limit order executions of NYSE-listed IPOs in pre- and post-decimalization periods. Consistent with previous studies, we find that the opening price captures almost all the initial return in pre- and post-decimalization period. The initial return is lower in post-decimalization period for the hot IPOs, suggesting that the probability of front-running is higher and the benefit is minimized from buying at the bid after decimal pricing.

The intraday return pattern also implies that the day traders are unable to profit from buying and selling the newly listed issues in aftermarket trading, except those who subscribe for shares in new issues at the offer price. In the post-decimalization, the day traders will earn negative cumulative return for hot IPOs.

The volatility is higher at the start of trading of IPOs, indicating that the rate of information resolution is high during this period. However, the volatility is lower, especially at the start of trading, throughout the day in the post-decimalization period. This result suggests that the decrease in volatility after decimalization might reflect changing information flows. The higher probability of front-running and adverse selection cost in post-decimalization reduce the incentives of traders to reveal their interests in the newly listed issues, especially for more underpriced IPOs.

The intraday volatility of less underpriced IPOs does not change much in pre- and post-decimalization period. We argue that the information contained in cold IPOs is higher and certain than that of in hot IPOs, as underwriter gives the institutions a chance (put options) to sell back their allocation at offer price in the form of supporting the cold

IPOs. Thus, given the same set of large sell information for cold IPOs, the intraday volatility pattern is similar in pre- and post-decimalization.

The proportion of limit order executions is lower after decimalization due to the lower displayed liquidity and the smaller transaction cost of submitting market orders. The intraday results show that the proportion of limit orders execution is higher at the start of trading and stabilizes after one hour of trading in pre- and post-decimalization. In addition, the proportions of limit orders executions are lower at the start of trading for hot and warm IPOs after decimal pricing, suggesting that the traders feel less costly to switch to market orders in response to the rapid initial price movements. However, the proportion of limit order executions for cold IPOs at the start of trading does not reduce as much as hot and warm IPOs after decimalization. This result in not surprising that the non-execution rate of submitting limit orders is much lower in cold IPOs.

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Table 1 Sample Descriptive

This table presents the descriptive statistics for the offer and trading characteristics in Panel A and B, respectively. Shares offered is number of shares issued by IPO firms. Net proceeds is the total amount excluding fees and expenses raised by issuers. Offer price is the final subscription price of IPO shares. Filing Price Range is defined as the difference between high and low filing price as the percent of the low filing price. Offer (open) to open (close) returns is the difference between the opening (closing) price and offer (opening) price as the percent of the offer price. Shares outstanding is the number of shares outstanding after IPO listing. Market capitalization is defined as post-IPO shares outstanding times the first day closing stock price. We measure quoted and effective spreads in term of dollar and proportion. Quoted spreads are computed based on time-weighted average, whereas effective spreads based on trade-weighted average. Depth is the sum of bid and ask depth measured in terms of dollar and share. Trading volume is average shares traded. Range is the difference between high and low prices divided by the average price. Number of trade is the total number of transaction. ** and *** represent 5% and 1% significant level, respectively.

	Pre-decimalization			Post-decimalization			Differences	
	Mean	Median	Standard deviation	Mean	Median	Standard deviation	Mean	Median
Panel A Offer characteristics								
Shares Offered (M)	26.38	11.05	44.55	31.01	14.00	67.20	4.63	2.95*
							(0.62)	(1.87)
Net Proceeds ($M)	509.04	144.86	1,060.38	532.99	212.52	939.99	23.95	67.66***
							(0.18)	(2.79)
Offer Price	18.73	17.00	9.97	19.16	18.00	7.47	0.43	1.00
							(0.37)	(1.22)
Offer to Open Returns (%)	14.00	8.21	21.53	9.55	7.23	12.16	-4.45*	-0.98
							(-1.93)	(0.87)
Open to Close Returns (%)	0.52	0.00	5.64	1.00	0.34	4.89	0.48	0.34
							(0.68)	(0.81)
Filing Price Range (%)	15.71	14.64	6.43	13.36	13.33	5.78	-2.35***	-1.31***
							(-2.92)	(-4.03)
Market Capitalization ($M)	2,550.66	684.80	5,752.83	2,070.05	973.49	3,451.42	-480.61	288.69**
							(-0.77)	(2.03)

Table 1 (continued)

	Pre-decimalization			Post-decimalization			Differences	
	Mean	Median	Standard deviation	Mean	Median	Standard deviation	Mean	Median
Panel B Trading Characteristics								
Quoted Percentage Spread	0.0063	0.0056	0.0036	0.0028	0.0026	0.0013	-0.0035***	-0.0030***
							(-9.92)	(-10.98)
Effective Dollar Spread	0.1023	0.0743	0.1155	0.0674	0.0510	0.0614	-0.0349***	-0.0233***
							(-2.87)	(-6.35)
Effective Percentage Spread	0.0048	0.0042	0.0031	0.0035	0.0028	0.0036	-0.0013***	-0.0014***
							(-3.07)	(-6.42)
Trading Volume	6500.04	5812.28	4003.73	5785.59	4770.87	4025.34	-714.45	-1041.41
							(-1.35)	(-1.59)
Dollar Depth ($1,000)	966.34	651.67	932.28	481.71	296.66	618.20	-483.63***	-355.01***
							(-4.62)	(-5.89)
Share Depth (round lots)	525.33	345.71	588.97	325.17	217.18	495.36	-200.16***	-128.53***
							(-3.03)	(-4.81)
Range	0.0778	0.0597	0.0690	0.0637	0.0547	0.0369	-0.0141*	-0.0050
							(-1.94)	(-0.56)
Num of Trade	2,583.42	979.00	5,723.68	2,080.08	1,639.00	2,235.29	-503.34	660.00***
							(-0.88)	(3.97)
Num of Quote	776.43	622.00	615.24	1,695.85	1,546.00	1,016.59	919.42***	924.00***
							(8.32)	(8.33)

Table 2 Intraday pattern of returns

This table presents the intraday returns of all, hot, warm, and cold IPOs in Panels A, B, C, and D, respectively. Intraday return is defined as the logarithm of the ratio of the last and the first traded prices during that interval. Interval 0 represents the offer-to-open returns, and interval 1 to 60 is based on each 5-minute of the aftermarket trading of IPOs.

Panel A The intraday returns of all IPOs

	Pre-decimalization							Post-decimalization						
Interval	Mean	t	prob > t	Max	Min	Cumret 0-60	Cumret 1-60	Mean	t	prob > t	Max	Min	Cumret 0-60	Cumret 1-60
0	0.11659	7.61418	0.00000	0.74639	-0.51794	0.11659		0.08496	8.04179	0.00000	0.38866	-0.57025	0.08496	
1	-0.00311	-1.79360	0.07553	0.12002	-0.06454	0.11348	-0.00311	-0.00221	-1.83005	0.06983	0.03974	-0.04899	0.08275	-0.00221
2	0.00083	0.57874	0.56391	0.06180	-0.03806	0.11431	-0.00228	-0.00323	-2.79083	0.00616	0.02703	-0.04441	0.07952	-0.00544
3	0.00070	0.44316	0.65849	0.03688	-0.10920	0.11501	-0.00158	0.00079	0.66455	0.50767	0.03754	-0.04652	0.08031	-0.00465
4	0.00225	1.55441	0.12286	0.10118	-0.04082	0.11726	0.00067	0.00051	0.60514	0.54628	0.03770	-0.02683	0.08081	-0.00415
5	0.00064	0.54167	0.58910	0.04754	-0.04703	0.11791	0.00132	0.00014	0.18858	0.85075	0.02296	-0.02667	0.08095	-0.00400
6	0.00119	0.99696	0.32089	0.05522	-0.04794	0.11910	0.00251	0.00060	0.81177	0.41860	0.02598	-0.03015	0.08155	-0.00341
7	0.00061	0.72926	0.46735	0.03509	-0.02292	0.11970	0.00311	0.00154	2.05668	0.04198	0.03214	-0.02557	0.08309	-0.00187
8	-0.00018	-0.14480	0.88512	0.03069	-0.08895	0.11953	0.00294	0.00007	0.11135	0.91153	0.01791	-0.04272	0.08316	-0.00180
9	-0.00031	-0.35195	0.72553	0.03206	-0.04581	0.11922	0.00263	0.00090	1.71757	0.08857	0.02469	-0.01199	0.08406	-0.00089
10	0.00041	0.53619	0.59289	0.04974	-0.02132	0.11962	0.00304	-0.00025	-0.53400	0.59437	0.02112	-0.01495	0.08381	-0.00114
11	0.00101	1.32347	0.18837	0.05297	-0.01412	0.12064	0.00405	-0.00090	-1.81317	0.07241	0.01201	-0.02495	0.08291	-0.00205
12	-0.00139	-1.64264	0.10326	0.01527	-0.04396	0.11925	0.00266	-0.00033	-0.65216	0.51561	0.01288	-0.01917	0.08258	-0.00237
13	0.00077	0.55995	0.57663	0.13859	-0.03989	0.12001	0.00342	0.00047	1.19525	0.23447	0.01239	-0.01560	0.08305	-0.00191
14	-0.00023	-0.35958	0.71984	0.03442	-0.03681	0.11978	0.00319	0.00015	0.33283	0.73987	0.01064	-0.03185	0.08320	-0.00176
15	-0.00018	-0.30256	0.76279	0.01446	-0.03629	0.11960	0.00301	0.00061	1.53011	0.12876	0.01216	-0.01509	0.08381	-0.00115
16	-0.00013	-0.15110	0.88017	0.04205	-0.05311	0.11947	0.00289	0.00047	1.40420	0.16298	0.01225	-0.00862	0.08428	-0.00067
17	-0.00013	-0.17136	0.86425	0.02462	-0.05399	0.11934	0.00275	0.00052	1.16533	0.24632	0.01628	-0.01114	0.08480	-0.00016
18	0.00002	0.02658	0.97884	0.02985	-0.02469	0.11936	0.00277	0.00001	0.03410	0.97285	0.01410	-0.02385	0.08481	-0.00014
19	-0.00024	-0.41587	0.67830	0.01460	-0.03676	0.11913	0.00254	0.00034	0.88383	0.37865	0.01342	-0.01905	0.08516	0.00020
20	-0.00033	-0.45527	0.64980	0.04432	-0.02684	0.11879	0.00220	0.00032	0.89274	0.37388	0.01677	-0.01089	0.08547	0.00052
21	0.00027	0.45658	0.64886	0.02684	-0.02326	0.11907	0.00248	0.00071	1.83811	0.06865	0.02068	-0.01246	0.08618	0.00122
22	-0.00017	-0.34783	0.72862	0.02339	-0.02770	0.11889	0.00231	0.00004	0.11250	0.91062	0.00960	-0.01558	0.08622	0.00126
23	0.00059	1.11574	0.26692	0.03380	-0.01004	0.11948	0.00289	-0.00009	-0.23846	0.81195	0.01926	-0.01166	0.08612	0.00116
24	-0.00036	-0.78446	0.43443	0.01021	-0.01835	0.11912	0.00253	0.00079	2.08830	0.03902	0.02533	-0.01409	0.08691	0.00196
25	-0.00030	-0.56802	0.57116	0.03509	-0.01757	0.11882	0.00223	0.00050	1.18312	0.23924	0.01721	-0.01504	0.08742	0.00246
26	0.00033	0.78625	0.43338	0.01961	-0.01439	0.11915	0.00256	0.00017	0.39343	0.69474	0.01814	-0.02634	0.08758	0.00263
27	-0.00039	-1.04664	0.29754	0.01415	-0.01642	0.11876	0.00217	0.00022	0.61302	0.54110	0.01342	-0.00878	0.08781	0.00285
28	0.00044	0.98452	0.32700	0.02641	-0.00678	0.11920	0.00261	-0.00002	-0.04847	0.96143	0.01513	-0.01475	0.08779	0.00283
29	-0.00077	-1.93279	0.05581	0.01473	-0.01156	0.11843	0.00184	0.00016	0.54484	0.58694	0.00839	-0.00948	0.08795	0.00299
30	0.00028	0.69739	0.48702	0.01808	-0.01432	0.11871	0.00212	0.00022	0.65132	0.51618	0.01264	-0.01303	0.08817	0.00321

Panel A of Table 2 (continued)

	Pre-decimalization							Post-decimalization						
Interval	Mean	t	prob > t	Max	Min	Cumret 0-60	Cumret 1-60	Mean	t	prob > t	Max	Min	Cumret 0-60	Cumret 1-60
31	0.00094	1.86181	0.06527	0.03572	-0.01173	0.11965	0.00306	0.00002	0.05182	0.95876	0.01057	-0.00948	0.08818	0.00322
32	0.00036	1.02776	0.30630	0.01263	-0.00873	0.12001	0.00342	0.00013	0.36900	0.71283	0.01052	-0.02675	0.08831	0.00335
33	-0.00018	-0.58793	0.55777	0.00834	-0.00952	0.11983	0.00325	0.00034	0.96837	0.33496	0.01503	-0.01230	0.08865	0.00369
34	-0.00010	-0.19542	0.84542	0.02849	-0.01508	0.11974	0.00315	0.00089	3.11658	0.00233	0.01119	-0.01264	0.08954	0.00458
35	-0.00059	-1.20801	0.22961	0.02327	-0.02198	0.11915	0.00256	0.00003	0.07617	0.93942	0.01330	-0.01152	0.08956	0.00461
36	0.00003	0.06985	0.94444	0.01250	-0.01399	0.11917	0.00259	0.00000	0.00153	0.99878	0.00966	-0.01212	0.08957	0.00461
37	0.00042	0.90832	0.36568	0.01183	-0.02403	0.11959	0.00300	0.00009	0.30183	0.76335	0.01558	-0.01335	0.08966	0.00470
38	0.00056	0.97970	0.32936	0.02053	-0.02939	0.12015	0.00356	0.00038	1.28383	0.20188	0.01518	-0.00957	0.09003	0.00508
39	-0.00012	-0.25990	0.79542	0.01147	-0.02229	0.12003	0.00344	-0.00013	-0.47018	0.63915	0.01003	-0.01369	0.08990	0.00494
40	0.00032	0.67689	0.49989	0.02070	-0.02157	0.12035	0.00376	0.00045	0.96701	0.33564	0.03734	-0.00850	0.09035	0.00539
41	0.00040	0.95017	0.34409	0.02065	-0.01250	0.12075	0.00416	0.00021	0.45392	0.65077	0.01757	-0.02679	0.09056	0.00560
42	0.00004	0.07262	0.94224	0.04232	-0.01639	0.12079	0.00420	0.00029	1.13111	0.26045	0.00787	-0.01401	0.09085	0.00589
43	0.00002	0.04132	0.96712	0.02710	-0.01835	0.12081	0.00422	0.00049	1.69483	0.09291	0.00967	-0.00778	0.09134	0.00639
44	0.00019	0.50484	0.61467	0.01515	-0.01070	0.12100	0.00441	-0.00002	-0.07148	0.94314	0.00994	-0.00783	0.09133	0.00637
45	0.00055	1.67459	0.09683	0.01807	-0.01087	0.12156	0.00497	0.00001	0.03263	0.97403	0.01245	-0.00858	0.09133	0.00638
46	-0.00027	-0.61173	0.54197	0.02429	-0.01504	0.12129	0.00470	0.00000	0.00062	0.99951	0.00989	-0.01856	0.09134	0.00638
47	0.00014	0.26986	0.78777	0.02105	-0.01969	0.12142	0.00483	0.00011	0.38300	0.70245	0.00951	-0.01259	0.09144	0.00649
48	-0.00050	-1.07560	0.28448	0.01942	-0.01815	0.12092	0.00433	0.00036	1.17792	0.24135	0.01044	-0.01869	0.09180	0.00685
49	0.00033	0.83578	0.40514	0.01550	-0.01295	0.12125	0.00466	0.00035	1.34414	0.18164	0.01016	-0.00705	0.09216	0.00720
50	0.00052	1.19421	0.23504	0.02076	-0.01631	0.12178	0.00519	0.00013	0.32156	0.74839	0.01522	-0.01983	0.09228	0.00733
51	0.00050	1.04745	0.29730	0.02062	-0.01012	0.12228	0.00569	0.00046	1.35679	0.17760	0.01162	-0.01507	0.09274	0.00778
52	0.00045	0.90771	0.36613	0.03015	-0.01376	0.12273	0.00614	0.00007	0.26709	0.78990	0.01105	-0.00814	0.09281	0.00785
53	-0.00005	-0.05891	0.95314	0.03150	-0.07487	0.12268	0.00609	0.00048	1.55124	0.12369	0.01482	-0.00604	0.09329	0.00833
54	-0.00022	-0.31079	0.75660	0.04027	-0.03077	0.12245	0.00586	-0.00017	-0.53770	0.59186	0.01157	-0.01296	0.09311	0.00816
55	-0.00093	-1.92519	0.05708	0.01227	-0.02151	0.12152	0.00493	0.00053	1.47075	0.14419	0.01588	-0.01084	0.09364	0.00868
56	0.00066	1.05166	0.29554	0.02179	-0.02410	0.12218	0.00559	0.00067	2.26677	0.02534	0.01325	-0.00700	0.09431	0.00935
57	-0.00111	-1.90642	0.05956	0.02031	-0.02639	0.12107	0.00448	0.00007	0.23194	0.81701	0.01306	-0.01037	0.09438	0.00942
58	-0.00004	-0.07801	0.93798	0.01136	-0.01537	0.12103	0.00444	-0.00040	-1.14588	0.25435	0.01434	-0.01237	0.09398	0.00902
59	-0.00020	-0.34265	0.73266	0.02994	-0.01319	0.12083	0.00424	0.00005	0.17046	0.86497	0.01072	-0.00777	0.09403	0.00908
60	0.00048	0.76948	0.44369	0.02751	-0.01793	0.12131	0.00473	0.00025	0.81172	0.41875	0.00988	-0.01053	0.09428	0.00933

Panel B The intraday returns of Hot IPOs

	Pre-decimalization							Post-decimalization						
Interval	Mean	t	prob > t	Max	Min	Cumret 0-60	Cumret 1-60	Mean	t	prob > t	Max	Min	Cumret 0-60	Cumret 1-60
0	0.23846	11.08891	0.00000	0.74639	0.09798	0.23846		0.18239	16.31287	0.00000	0.38866	0.10008	0.18239	
1	-0.00588	-1.74725	0.08650	0.12002	-0.04591	0.23258	-0.00588	-0.00652	-3.02001	0.00408	0.03633	-0.04899	0.17587	-0.00652
2	0.00178	0.67645	0.50175	0.06180	-0.03572	0.23437	-0.00410	-0.00400	-1.90750	0.06258	0.02703	-0.03455	0.17187	-0.01052
3	0.00088	0.38919	0.69872	0.03688	-0.06062	0.23524	-0.00322	0.00146	0.68831	0.49464	0.03754	-0.03769	0.17333	-0.00906
4	0.00275	1.03775	0.30419	0.10118	-0.04082	0.23799	-0.00047	-0.00037	-0.26412	0.79284	0.03770	-0.02683	0.17296	-0.00943
5	-0.00011	-0.04771	0.96213	0.04754	-0.04703	0.23788	-0.00058	0.00006	0.05162	0.95905	0.01391	-0.01718	0.17302	-0.00937
6	-0.00123	-0.61889	0.53869	0.03637	-0.04794	0.23665	-0.00181	0.00226	1.52667	0.13355	0.02598	-0.03015	0.17528	-0.00711
7	0.00203	1.36500	0.17813	0.03509	-0.02043	0.23867	0.00021	0.00293	2.16649	0.03538	0.03214	-0.01260	0.17821	-0.00418
8	-0.00067	-0.29705	0.76761	0.03069	-0.08895	0.23801	-0.00046	-0.00041	-0.30490	0.76178	0.01791	-0.04272	0.17780	-0.00459
9	0.00097	0.66932	0.50625	0.03206	-0.04581	0.23898	0.00052	0.00064	0.69086	0.49305	0.02469	-0.01131	0.17844	-0.00395
10	-0.00004	-0.03003	0.97616	0.04974	-0.02132	0.23894	0.00047	-0.00073	-0.83956	0.40540	0.02112	-0.01495	0.17772	-0.00467
11	0.00312	2.24814	0.02883	0.05297	-0.01351	0.24205	0.00359	-0.00234	-2.51727	0.01530	0.01201	-0.02495	0.17538	-0.00701
12	-0.00333	-2.15179	0.03608	0.01202	-0.04396	0.23873	0.00026	-0.00067	-0.79240	0.43211	0.01135	-0.01531	0.17471	-0.00768
13	0.00235	0.82994	0.41037	0.13859	-0.03989	0.24107	0.00261	0.00074	1.14814	0.25672	0.01239	-0.00993	0.17546	-0.00693
14	0.00031	0.25727	0.79799	0.03442	-0.03681	0.24139	0.00293	0.00011	0.12932	0.89766	0.01064	-0.03185	0.17556	-0.00683
15	-0.00056	-0.51727	0.60716	0.01446	-0.03629	0.24082	0.00236	0.00092	1.35002	0.18348	0.00959	-0.01509	0.17648	-0.00591
16	-0.00041	-0.24275	0.80916	0.04205	-0.05311	0.24042	0.00196	0.00058	0.98836	0.32804	0.01225	-0.00742	0.17706	-0.00533
17	0.00002	0.01077	0.99145	0.02462	-0.05399	0.24043	0.00197	-0.00011	-0.12861	0.89821	0.01628	-0.01114	0.17695	-0.00544
18	-0.00013	-0.10660	0.91552	0.02985	-0.02469	0.24030	0.00184	-0.00071	-0.87315	0.38702	0.01410	-0.02385	0.17624	-0.00615
19	0.00011	0.10587	0.91610	0.01460	-0.03676	0.24041	0.00195	0.00121	2.10619	0.04056	0.01342	-0.00678	0.17745	-0.00493
20	-0.00027	-0.18728	0.85217	0.04432	-0.02684	0.24014	0.00168	0.00023	0.36116	0.71959	0.01677	-0.01089	0.17768	-0.00470
21	0.00128	1.18661	0.24077	0.02684	-0.02191	0.24142	0.00296	0.00088	1.17011	0.24786	0.02068	-0.01246	0.17857	-0.00382
22	0.00006	0.07186	0.94299	0.01381	-0.02770	0.24148	0.00302	0.00003	0.04503	0.96427	0.00611	-0.01558	0.17859	-0.00380
23	0.00149	1.45756	0.15097	0.03380	-0.01004	0.24297	0.00451	0.00048	0.61166	0.54371	0.01926	-0.01056	0.17907	-0.00332
24	-0.00047	-0.54818	0.58592	0.01021	-0.01835	0.24250	0.00404	0.00095	1.94567	0.05769	0.00966	-0.00437	0.18002	-0.00237
25	-0.00015	-0.14405	0.88602	0.03509	-0.01757	0.24235	0.00389	-0.00039	-0.50096	0.61874	0.01721	-0.01504	0.17963	-0.00276
26	0.00068	0.92697	0.35822	0.01961	-0.01439	0.24303	0.00457	0.00053	0.63431	0.52895	0.01814	-0.02634	0.18016	-0.00223
27	-0.00038	-0.57400	0.56844	0.01415	-0.01642	0.24265	0.00419	0.00028	0.43155	0.66804	0.01184	-0.00857	0.18043	-0.00195
28	0.00122	1.49894	0.13994	0.02641	-0.00678	0.24386	0.00540	0.00024	0.42468	0.67301	0.01361	-0.01475	0.18067	-0.00172
29	-0.00103	-1.50982	0.13714	0.01473	-0.01156	0.24284	0.00438	0.00056	1.23956	0.22129	0.00839	-0.00618	0.18123	-0.00116
30	0.00043	0.62064	0.53755	0.01808	-0.01432	0.24327	0.00481	0.00048	0.76551	0.44780	0.01264	-0.01186	0.18171	-0.00068

Panel B of Table 2 (continued)

	Pre-decimalization							Post-decimalization						
Interval	Mean	t	prob > t	Max	Min	Cumret 0-60	Cumret 1-60	Mean	t	prob > t	Max	Min	Cumret 0-60	Cumret 1-60
31	0.00112	1.25297	0.21582	0.03572	-0.01173	0.24439	0.00592	0.00045	0.86450	0.39170	0.01057	-0.00799	0.18216	-0.00023
32	0.00082	1.32503	0.19096	0.01263	-0.00873	0.24521	0.00675	-0.00040	-0.59618	0.55392	0.00608	-0.02675	0.18176	-0.00063
33	0.00024	0.50974	0.61239	0.00834	-0.00722	0.24545	0.00698	-0.00020	-0.34422	0.73222	0.01286	-0.01230	0.18156	-0.00083
34	-0.00001	-0.01912	0.98482	0.02849	-0.01250	0.24543	0.00697	0.00054	1.15892	0.25234	0.01119	-0.01264	0.18210	-0.00029
35	-0.00011	-0.13341	0.89438	0.02327	-0.01585	0.24532	0.00686	-0.00024	-0.45219	0.65321	0.00810	-0.01152	0.18186	-0.00053
36	-0.00005	-0.08118	0.93561	0.01048	-0.01399	0.24527	0.00681	0.00058	1.27233	0.20952	0.00966	-0.01070	0.18245	0.00006
37	0.00108	1.80730	0.07650	0.01183	-0.01031	0.24635	0.00789	0.00097	1.92278	0.06058	0.01558	-0.00420	0.18342	0.00103
38	0.00083	0.84664	0.40108	0.02053	-0.02939	0.24717	0.00871	0.00096	1.68648	0.09833	0.01518	-0.00957	0.18438	0.00199
39	0.00031	0.37707	0.70766	0.01147	-0.02229	0.24749	0.00903	-0.00007	-0.11573	0.90836	0.01003	-0.01369	0.18431	0.00192
40	0.00180	2.39115	0.02045	0.02070	-0.01238	0.24928	0.01082	0.00064	0.64644	0.52114	0.03734	-0.00755	0.18495	0.00256
41	0.00036	0.48663	0.62856	0.02065	-0.01250	0.24964	0.01118	0.00051	0.73400	0.46660	0.01757	-0.01186	0.18546	0.00307
42	0.00070	0.71816	0.47587	0.04232	-0.01639	0.25034	0.01188	0.00035	0.97385	0.33512	0.00640	-0.00916	0.18580	0.00342
43	0.00043	0.51209	0.61076	0.02710	-0.01595	0.25077	0.01231	0.00081	1.89743	0.06392	0.00858	-0.00427	0.18662	0.00423
44	-0.00016	-0.33247	0.74087	0.00969	-0.01070	0.25061	0.01214	-0.00048	-1.17806	0.24470	0.00608	-0.00783	0.18614	0.00375
45	0.00036	0.80155	0.42646	0.00911	-0.01087	0.25096	0.01250	0.00017	0.38299	0.70345	0.00748	-0.00858	0.18631	0.00392
46	0.00021	0.33069	0.74221	0.01802	-0.01376	0.25117	0.01271	-0.00032	-0.48617	0.62910	0.00989	-0.01856	0.18598	0.00359
47	0.00009	0.10361	0.91788	0.01550	-0.01969	0.25125	0.01279	0.00086	1.88677	0.06538	0.00951	-0.00587	0.18684	0.00445
48	-0.00047	-0.57667	0.56665	0.01942	-0.01815	0.25078	0.01232	0.00155	3.70504	0.00056	0.01044	-0.00304	0.18839	0.00600
49	0.00079	1.38364	0.17249	0.01342	-0.01295	0.25157	0.01310	0.00071	1.48002	0.14554	0.01016	-0.00705	0.18910	0.00671
50	0.00090	1.09865	0.27708	0.02076	-0.01631	0.25246	0.01400	0.00069	0.90668	0.36920	0.01522	-0.01983	0.18979	0.00740
51	0.00104	1.27823	0.20696	0.02062	-0.01012	0.25350	0.01504	0.00061	1.06087	0.29417	0.01162	-0.01507	0.19040	0.00801
52	0.00111	1.21918	0.22838	0.03015	-0.01376	0.25461	0.01615	-0.00019	-0.42665	0.67158	0.00651	-0.00814	0.19020	0.00781
53	-0.00100	-0.59628	0.55362	0.03150	-0.07487	0.25361	0.01515	0.00063	1.31422	0.19515	0.01360	-0.00501	0.19083	0.00844
54	0.00055	0.45235	0.65293	0.04027	-0.01697	0.25416	0.01569	-0.00004	-0.05781	0.95414	0.01157	-0.01296	0.19079	0.00840
55	-0.00094	-1.33235	0.18867	0.01227	-0.02056	0.25322	0.01475	0.00006	0.09328	0.92608	0.01465	-0.01084	0.19085	0.00846
56	0.00048	0.47641	0.63582	0.02179	-0.02410	0.25370	0.01524	0.00109	2.12334	0.03902	0.00915	-0.00669	0.19194	0.00955
57	-0.00065	-0.73704	0.46448	0.02031	-0.02157	0.25305	0.01459	0.00061	1.16755	0.24888	0.01306	-0.00496	0.19255	0.01016
58	0.00015	0.20170	0.84100	0.01136	-0.01537	0.25320	0.01474	0.00065	1.07090	0.28968	0.01434	-0.00791	0.19320	0.01081
59	0.00012	0.11420	0.90959	0.02994	-0.01258	0.25332	0.01486	0.00006	0.12056	0.90455	0.00998	-0.00625	0.19326	0.01087
60	0.00004	0.03670	0.97090	0.02751	-0.01793	0.25336	0.01490	0.00072	1.25950	0.21407	0.00988	-0.00678	0.19397	0.01159

Panel C The intraday returns of Warm IPOs

	Pre-decimalization							Post-decimalization						
Interval	Mean	t	prob > t	Max	Min	Cumret 0-60	Cumret 1-60	Mean	t	prob > t	Max	Min	Cumret 0-60	Cumret 1-60
0	0.04111	8.97334	0.00000	0.09531	0.00673	0.04111		0.04529	9.49589	0.00000	0.09531	0.00043	0.04529	
1	-0.00088	-0.51341	0.61119	0.02132	-0.02053	0.04024	-0.00088	0.00058	0.29604	0.76877	0.03974	-0.02603	0.04587	0.00058
2	0.00071	0.32318	0.74866	0.03413	-0.01749	0.04095	-0.00016	-0.00410	-2.24639	0.03042	0.01941	-0.04441	0.04176	-0.00352
3	0.00131	0.66786	0.50901	0.03371	-0.02553	0.04226	0.00115	0.00269	1.84095	0.07325	0.02806	-0.01575	0.04445	-0.00084
4	0.00087	0.69276	0.49345	0.01911	-0.01527	0.04313	0.00202	0.00031	0.24137	0.81053	0.01630	-0.01933	0.04476	-0.00053
5	0.00041	0.29539	0.76960	0.01432	-0.01760	0.04354	0.00243	0.00065	0.53820	0.59350	0.02043	-0.01439	0.04541	0.00012
6	0.00368	1.99071	0.05511	0.04935	-0.01406	0.04722	0.00611	-0.00154	-1.82092	0.07630	0.00797	-0.01166	0.04387	-0.00142
7	-0.00101	-0.88665	0.38188	0.00995	-0.02292	0.04621	0.00509	-0.00101	-0.94962	0.34815	0.01007	-0.02557	0.04286	-0.00242
8	0.00080	0.39744	0.69368	0.01929	-0.05059	0.04701	0.00590	-0.00025	-0.28267	0.77893	0.01113	-0.02116	0.04261	-0.00268
9	-0.00262	-1.59240	0.12113	0.01393	-0.03803	0.04439	0.00328	0.00047	0.53197	0.59777	0.01735	-0.01199	0.04308	-0.00221
10	0.00040	0.33079	0.74296	0.02299	-0.01319	0.04479	0.00368	0.00038	0.56852	0.57294	0.01138	-0.00822	0.04346	-0.00183
11	0.00023	0.26244	0.79466	0.00755	-0.01379	0.04503	0.00392	-0.00057	-0.79782	0.42981	0.00987	-0.01005	0.04289	-0.00240
12	0.00180	1.94948	0.06005	0.01527	-0.00833	0.04682	0.00571	0.00089	1.36221	0.18095	0.01288	-0.00684	0.04378	-0.00150
13	0.00031	0.43048	0.66973	0.00963	-0.00781	0.04714	0.00602	0.00012	0.23834	0.81287	0.00868	-0.00701	0.04390	-0.00139
14	-0.00025	-0.43441	0.66690	0.00755	-0.00917	0.04689	0.00577	0.00012	0.17316	0.86342	0.00929	-0.01410	0.04402	-0.00127
15	-0.00017	-0.21167	0.83370	0.00930	-0.01515	0.04672	0.00561	0.00025	0.42742	0.67142	0.01216	-0.01018	0.04427	-0.00102
16	-0.00072	-0.95811	0.34519	0.01033	-0.01389	0.04600	0.00489	0.00057	1.23426	0.22449	0.01183	-0.00550	0.04484	-0.00045
17	-0.00007	-0.08429	0.93335	0.00992	-0.01425	0.04593	0.00482	0.00097	1.39793	0.17004	0.01479	-0.00669	0.04581	0.00052
18	0.00145	1.74887	0.08990	0.01373	-0.00798	0.04738	0.00627	0.00070	1.40051	0.16927	0.01024	-0.00623	0.04651	0.00123
19	-0.00078	-1.05213	0.30062	0.01258	-0.00897	0.04660	0.00549	-0.00023	-0.54917	0.58602	0.00551	-0.01155	0.04628	0.00100
20	-0.00039	-0.53155	0.59871	0.01242	-0.00573	0.04621	0.00510	0.00006	0.16537	0.86951	0.00910	-0.00602	0.04634	0.00106
21	0.00090	1.46275	0.15329	0.00755	-0.00575	0.04710	0.00599	0.00030	0.74902	0.45834	0.00765	-0.00407	0.04664	0.00135
22	-0.00061	-1.10777	0.27622	0.00395	-0.00909	0.04650	0.00538	0.00034	0.77601	0.44255	0.00664	-0.01077	0.04699	0.00170
23	-0.00145	-3.15723	0.00346	0.00255	-0.00873	0.04505	0.00394	-0.00057	-1.32950	0.19161	0.00765	-0.01094	0.04641	0.00113
24	-0.00010	-0.20582	0.83824	0.00749	-0.00585	0.04495	0.00384	0.00058	1.16510	0.25124	0.00791	-0.00732	0.04700	0.00171
25	-0.00021	-0.40328	0.68943	0.00587	-0.00985	0.04475	0.00364	0.00098	1.63208	0.11092	0.01271	-0.01031	0.04797	0.00269
26	-0.00036	-0.54066	0.59249	0.01342	-0.00886	0.04439	0.00328	-0.00042	-0.63254	0.53082	0.00731	-0.01809	0.04755	0.00227
27	-0.00032	-0.66931	0.50810	0.00480	-0.00717	0.04408	0.00296	0.00052	0.96171	0.34228	0.01342	-0.00796	0.04807	0.00278
28	-0.00024	-0.49181	0.62621	0.00985	-0.00596	0.04383	0.00272	-0.00056	-1.49567	0.14300	0.00627	-0.00498	0.04751	0.00223
29	-0.00070	-1.36346	0.18225	0.00647	-0.00749	0.04313	0.00202	-0.00041	-0.82245	0.41595	0.00766	-0.00948	0.04710	0.00182
30	0.00009	0.17892	0.85913	0.00881	-0.00694	0.04322	0.00211	-0.00003	-0.10614	0.91603	0.00446	-0.00590	0.04707	0.00178

Panel C of Table 2 (continued)

	Pre-decimalization							Post-decimalization						
Interval	Mean	t	prob > t	Max	Min	Cumret 0-60	Cumret 1-60	Mean	t	prob > t	Max	Min	Cumret 0-60	Cumret 1-60
31	0.00057	0.85619	0.39826	0.01126	-0.00662	0.04379	0.00268	0.00017	0.41644	0.67943	0.00990	-0.00651	0.04724	0.00196
32	-0.00017	-0.34429	0.73288	0.00685	-0.00741	0.04363	0.00251	0.00055	1.65152	0.10687	0.00908	-0.00356	0.04779	0.00250
33	-0.00076	-1.32083	0.19593	0.00445	-0.00952	0.04287	0.00176	0.00081	1.33920	0.18846	0.01503	-0.00402	0.04860	0.00332
34	-0.00001	-0.01968	0.98442	0.00957	-0.01508	0.04286	0.00174	0.00154	3.92474	0.00035	0.00960	-0.00240	0.05014	0.00486
35	-0.00077	-1.36879	0.18060	0.00631	-0.00746	0.04208	0.00097	0.00036	0.88573	0.38134	0.01081	-0.00403	0.05051	0.00522
36	-0.00007	-0.10302	0.91859	0.01250	-0.00826	0.04201	0.00090	-0.00021	-0.55004	0.58551	0.00384	-0.00948	0.05030	0.00501
37	-0.00098	-0.93200	0.35832	0.00743	-0.02403	0.04103	-0.00008	-0.00058	-1.17809	0.24609	0.00363	-0.01335	0.04972	0.00443
38	0.00056	0.75488	0.45584	0.01408	-0.00667	0.04159	0.00047	-0.00020	-0.60916	0.54605	0.00358	-0.00689	0.04952	0.00424
39	-0.00052	-0.89069	0.37974	0.00823	-0.00830	0.04107	-0.00005	-0.00016	-0.47230	0.63942	0.00760	-0.00430	0.04936	0.00408
40	-0.00069	-0.79600	0.43190	0.00647	-0.02157	0.04038	-0.00073	-0.00040	-0.99390	0.32656	0.00449	-0.00850	0.04896	0.00368
41	0.00087	1.45116	0.15647	0.00966	-0.00699	0.04125	0.00014	-0.00025	-0.28050	0.78061	0.01733	-0.02679	0.04872	0.00343
42	-0.00064	-1.23824	0.22464	0.00623	-0.00755	0.04061	-0.00050	0.00035	0.64247	0.52443	0.00749	-0.01401	0.04906	0.00377
43	-0.00113	-1.38011	0.17712	0.01238	-0.01835	0.03948	-0.00163	0.00002	0.04296	0.96596	0.00878	-0.00778	0.04908	0.00379
44	0.00100	1.12839	0.26754	0.01515	-0.00930	0.04048	-0.00064	0.00063	1.64592	0.10803	0.00994	-0.00357	0.04972	0.00443
45	0.00107	1.43122	0.16206	0.01807	-0.00445	0.04155	0.00043	0.00011	0.23790	0.81323	0.01245	-0.00480	0.04982	0.00453
46	-0.00070	-0.67639	0.50366	0.02429	-0.01504	0.04085	-0.00026	0.00010	0.42515	0.67313	0.00540	-0.00295	0.04992	0.00464
47	-0.00035	-0.52319	0.60444	0.00966	-0.00913	0.04050	-0.00061	-0.00019	-0.61769	0.54047	0.00377	-0.00439	0.04973	0.00444
48	-0.00130	-1.90804	0.06539	0.00736	-0.01606	0.03920	-0.00191	-0.00068	-1.18405	0.24375	0.00438	-0.01869	0.04905	0.00377
49	-0.00042	-0.75896	0.45343	0.00806	-0.00752	0.03879	-0.00233	0.00036	1.00589	0.32083	0.00635	-0.00421	0.04941	0.00413
50	-0.00002	-0.04227	0.96655	0.00462	-0.00752	0.03877	-0.00234	-0.00002	-0.03351	0.97344	0.00682	-0.00997	0.04939	0.00411
51	-0.00052	-0.73849	0.46577	0.01019	-0.00972	0.03825	-0.00286	-0.00026	-0.44661	0.65769	0.01126	-0.01141	0.04913	0.00385
52	-0.00048	-0.91050	0.36958	0.00673	-0.00830	0.03777	-0.00334	-0.00034	-0.86653	0.39164	0.00442	-0.00679	0.04880	0.00351
53	0.00129	2.21557	0.03445	0.00913	-0.00480	0.03905	-0.00206	0.00018	0.32305	0.74843	0.01482	-0.00604	0.04898	0.00369
54	-0.00047	-0.81296	0.42287	0.00615	-0.00660	0.03859	-0.00253	-0.00015	-0.38010	0.70599	0.00615	-0.00635	0.04883	0.00354
55	-0.00102	-1.47384	0.15168	0.00449	-0.01217	0.03757	-0.00354	0.00090	1.70004	0.09730	0.01588	-0.00519	0.04973	0.00444
56	0.00053	0.52714	0.60240	0.01848	-0.00833	0.03811	-0.00301	-0.00028	-0.74976	0.45802	0.00451	-0.00700	0.04945	0.00416
57	-0.00118	-1.63078	0.11455	0.00407	-0.01460	0.03693	-0.00419	-0.00043	-0.94933	0.34845	0.00609	-0.01037	0.04902	0.00373
58	0.00033	0.55380	0.58445	0.00505	-0.00930	0.03726	-0.00385	-0.00120	-2.49432	0.01721	0.00440	-0.01237	0.04782	0.00254
59	-0.00020	-0.28179	0.78034	0.00971	-0.00763	0.03707	-0.00405	0.00001	0.02940	0.97670	0.01072	-0.00676	0.04784	0.00255
60	0.00101	1.73172	0.09517	0.00962	-0.00465	0.03808	-0.00304	-0.00010	-0.21922	0.82775	0.00727	-0.01053	0.04774	0.00245

Panel D The intraday returns of Cold IPOs

	Pre-decimalization							Post-decimalization						
Interval	Mean	t	prob > t	Max	Min	Cumret 0-60	Cumret 1-60	Mean	t	prob > t	Max	Min	Cumret 0-60	Cumret 1-60
0	-0.02026	-1.13453	0.26619	0.00000	-0.51794	-0.02026		-0.02540	-1.25068	0.22178	0.00000	-0.57025	-0.02540	
1	-0.00060	-0.25595	0.79986	0.00778	-0.06454	-0.02085	-0.00060	0.00119	0.86570	0.39428	0.01770	-0.02109	-0.02420	0.00119
2	-0.00078	-0.43590	0.66625	0.02643	-0.03806	-0.02163	-0.00137	-0.00067	-0.36703	0.71646	0.01933	-0.02985	-0.02487	0.00052
3	-0.00030	-0.06937	0.94518	0.03652	-0.10920	-0.02193	-0.00167	-0.00307	-1.22359	0.23168	0.02647	-0.04652	-0.02795	-0.00255
4	0.00291	1.03821	0.30806	0.07276	-0.02004	-0.01902	0.00124	0.00230	1.35005	0.18821	0.02508	-0.01719	-0.02565	-0.00025
5	0.00228	1.63692	0.11284	0.03509	-0.01227	-0.01673	0.00352	-0.00045	-0.28731	0.77607	0.02296	-0.02667	-0.02610	-0.00071
6	0.00279	1.33904	0.19133	0.05522	-0.01286	-0.01395	0.00631	0.00081	0.74995	0.45977	0.01013	-0.01749	-0.02529	0.00011
7	-0.00017	-0.13304	0.89515	0.02177	-0.01667	-0.01412	0.00614	0.00278	2.23594	0.03382	0.02630	-0.00738	-0.02251	0.00288
8	-0.00039	-0.47004	0.64210	0.01285	-0.01325	-0.01451	0.00574	0.00137	1.72422	0.09610	0.01337	-0.00589	-0.02115	0.00425
9	-0.00002	-0.01525	0.98795	0.01887	-0.01724	-0.01453	0.00572	0.00196	2.50069	0.01876	0.01152	-0.00635	-0.01918	0.00621
10	0.00129	1.31753	0.19915	0.01527	-0.00749	-0.01324	0.00702	-0.00033	-0.41596	0.68073	0.01410	-0.00947	-0.01951	0.00588
11	-0.00217	-2.11088	0.04456	0.00528	-0.01412	-0.01541	0.00485	0.00107	1.53052	0.13752	0.00968	-0.00627	-0.01844	0.00695
12	-0.00149	-1.20808	0.23789	0.01290	-0.01644	-0.01690	0.00336	-0.00152	-1.36207	0.18486	0.00866	-0.01917	-0.01996	0.00544
13	-0.00179	-1.71325	0.09857	0.00766	-0.01862	-0.01868	0.00158	0.00050	0.50481	0.61795	0.01109	-0.01560	-0.01946	0.00593
14	-0.00129	-1.14992	0.26064	0.01170	-0.01695	-0.01997	0.00029	0.00026	0.42353	0.67539	0.00573	-0.01105	-0.01920	0.00619
15	0.00057	0.77838	0.44337	0.01156	-0.00473	-0.01940	0.00086	0.00060	0.71186	0.48289	0.00837	-0.01277	-0.01860	0.00679
16	0.00115	1.38594	0.17754	0.01515	-0.00519	-0.01825	0.00201	0.00015	0.20221	0.84133	0.00882	-0.00862	-0.01845	0.00694
17	-0.00050	-0.65920	0.51556	0.00844	-0.00645	-0.01874	0.00151	0.00095	1.66278	0.10837	0.00937	-0.00442	-0.01751	0.00789
18	-0.00144	-1.79055	0.08502	0.00772	-0.01130	-0.02019	0.00007	0.00028	0.45876	0.65022	0.00886	-0.00539	-0.01723	0.00817
19	-0.00024	-0.28547	0.77755	0.01130	-0.00846	-0.02043	-0.00018	-0.00035	-0.30674	0.76148	0.00932	-0.01905	-0.01758	0.00782
20	-0.00039	-0.44408	0.66066	0.00766	-0.01130	-0.02082	-0.00056	0.00085	0.99908	0.32696	0.01217	-0.00664	-0.01673	0.00867
21	-0.00246	-2.51239	0.01853	0.00406	-0.02326	-0.02328	-0.00302	0.00100	1.32738	0.19592	0.01043	-0.00513	-0.01573	0.00967
22	-0.00009	-0.08929	0.92953	0.02339	-0.00870	-0.02337	-0.00312	-0.00039	-0.70257	0.48856	0.00960	-0.00671	-0.01612	0.00927
23	0.00129	2.47880	0.01999	0.00840	-0.00438	-0.02208	-0.00182	-0.00042	-0.58971	0.56048	0.00587	-0.01166	-0.01655	0.00885
24	-0.00048	-0.59794	0.55505	0.00837	-0.01222	-0.02256	-0.00230	0.00082	0.70666	0.48606	0.02533	-0.01409	-0.01572	0.00967
25	-0.00070	-1.35355	0.18753	0.00326	-0.00778	-0.02326	-0.00300	0.00140	1.85267	0.07531	0.01120	-0.00645	-0.01432	0.01107
26	0.00047	0.81692	0.42140	0.00766	-0.00567	-0.02278	-0.00253	0.00037	1.06604	0.29621	0.00419	-0.00340	-0.01395	0.01145
27	-0.00048	-0.80326	0.42940	0.00778	-0.00587	-0.02327	-0.00301	-0.00032	-0.47339	0.64004	0.00902	-0.00878	-0.01427	0.01112
28	-0.00030	-0.44324	0.66140	0.00772	-0.00560	-0.02356	-0.00331	0.00033	0.45496	0.65307	0.01513	-0.00683	-0.01394	0.01145
29	-0.00032	-0.40688	0.68756	0.00772	-0.00766	-0.02388	-0.00362	0.00027	0.48864	0.62935	0.00647	-0.00839	-0.01368	0.01172
30	0.00020	0.27056	0.78895	0.00966	-0.00778	-0.02368	-0.00342	0.00012	0.14936	0.88246	0.01176	-0.01303	-0.01356	0.01184

Panel D of Table 2 (continued)

	Pre-decimalization							Post-decimalization						
Interval	Mean	t	prob > t	Max	Min	Cumret 0-60	Cumret 1-60	Mean	t	prob > t	Max	Min	Cumret 0-60	Cumret 1-60
31	0.00105	1.18868	0.24573	0.01105	-0.00766	-0.02262	-0.00237	-0.00102	-1.74633	0.09303	0.00409	-0.00948	-0.01458	0.01082
32	0.00010	0.16785	0.86806	0.00587	-0.00846	-0.02253	-0.00227	0.00047	0.73751	0.46796	0.01052	-0.00610	-0.01411	0.01128
33	-0.00029	-0.56638	0.57618	0.00436	-0.00778	-0.02281	-0.00256	0.00064	1.07977	0.29098	0.01009	-0.00350	-0.01348	0.01192
34	-0.00037	-0.29437	0.77091	0.02222	-0.01422	-0.02318	-0.00293	0.00056	0.82224	0.41903	0.00794	-0.00759	-0.01291	0.01248
35	-0.00134	-1.29537	0.20703	0.00587	-0.02198	-0.02452	-0.00427	0.00001	0.00814	0.99357	0.01330	-0.00979	-0.01291	0.01249
36	0.00032	0.46305	0.64733	0.01105	-0.00587	-0.02421	-0.00395	-0.00079	-1.20953	0.23824	0.00468	-0.01212	-0.01370	0.01170
37	0.00084	1.11469	0.27558	0.01105	-0.00766	-0.02336	-0.00311	-0.00056	-1.15976	0.25755	0.00506	-0.00590	-0.01426	0.01114
38	0.00001	0.00885	0.99301	0.01486	-0.00816	-0.02335	-0.00310	0.00016	0.30735	0.76123	0.00503	-0.00528	-0.01410	0.01130
39	-0.00049	-0.76882	0.44920	0.00816	-0.01163	-0.02384	-0.00359	-0.00022	-0.59667	0.55632	0.00286	-0.00653	-0.01432	0.01108
40	-0.00139	-2.15466	0.04102	0.00583	-0.00889	-0.02524	-0.00498	0.00142	2.36644	0.02637	0.00678	-0.00645	-0.01290	0.01250
41	-0.00012	-0.17684	0.86106	0.00778	-0.01105	-0.02536	-0.00510	0.00033	0.44605	0.65956	0.01342	-0.00643	-0.01257	0.01283
42	-0.00045	-0.61393	0.54481	0.01093	-0.00778	-0.02580	-0.00555	0.00011	0.24214	0.81073	0.00787	-0.00437	-0.01246	0.01294
43	0.00065	0.64932	0.52205	0.01644	-0.00861	-0.02516	-0.00490	0.00063	0.86966	0.39310	0.00967	-0.00660	-0.01183	0.01356
44	-0.00010	-0.14417	0.88652	0.00592	-0.00985	-0.02525	-0.00500	-0.00016	-0.25995	0.79712	0.00563	-0.00643	-0.01199	0.01341
45	0.00030	0.52649	0.60319	0.00957	-0.00409	-0.02495	-0.00469	-0.00046	-1.25678	0.22093	0.00291	-0.00513	-0.01245	0.01295
46	-0.00071	-1.13648	0.26653	0.00858	-0.00778	-0.02566	-0.00541	0.00047	0.93912	0.35702	0.00594	-0.00550	-0.01198	0.01342
47	0.00089	0.75382	0.45829	0.02105	-0.00844	-0.02477	-0.00451	-0.00086	-1.18899	0.24608	0.00613	-0.01259	-0.01284	0.01256
48	0.00054	0.89839	0.37829	0.01149	-0.00480	-0.02423	-0.00397	-0.00030	-0.54579	0.59025	0.00356	-0.00935	-0.01314	0.01226
49	0.00036	0.33701	0.73931	0.01550	-0.00778	-0.02387	-0.00361	-0.00034	-0.74159	0.46553	0.00469	-0.00671	-0.01348	0.01192
50	0.00046	0.63404	0.53259	0.01460	-0.00501	-0.02341	-0.00315	-0.00074	-1.34543	0.19106	0.00277	-0.01124	-0.01422	0.01118
51	0.00073	0.91566	0.37024	0.00849	-0.00778	-0.02269	-0.00243	0.00129	2.85977	0.00864	0.00606	-0.00200	-0.01293	0.01247
52	0.00024	0.40182	0.69208	0.00778	-0.00419	-0.02245	-0.00219	0.00122	2.16248	0.04077	0.01105	-0.00281	-0.01171	0.01369
53	0.00035	0.53759	0.59710	0.00866	-0.00432	-0.02210	-0.00185	0.00065	1.19378	0.24423	0.00812	-0.00345	-0.01106	0.01434
54	-0.00196	-1.14100	0.26882	0.00421	-0.03077	-0.02406	-0.00380	-0.00048	-0.78737	0.43877	0.00905	-0.00468	-0.01154	0.01386
55	-0.00080	-0.58972	0.56271	0.00813	-0.02151	-0.02486	-0.00460	0.00085	1.13185	0.26888	0.00897	-0.00649	-0.01069	0.01471
56	0.00133	1.40159	0.17804	0.01575	-0.00445	-0.02353	-0.00327	0.00133	2.20553	0.03724	0.01325	-0.00160	-0.00936	0.01604
57	-0.00235	-1.49812	0.15244	0.00443	-0.02639	-0.02587	-0.00562	-0.00020	-0.34677	0.73191	0.00861	-0.00794	-0.00956	0.01584
58	-0.00110	-1.20904	0.24319	0.00778	-0.00849	-0.02697	-0.00672	-0.00121	-2.04526	0.05243	0.00794	-0.00651	-0.01077	0.01463
59	-0.00102	-0.98501	0.33843	0.00528	-0.01319	-0.02800	-0.00774	0.00009	0.15173	0.88072	0.00518	-0.00777	-0.01068	0.01471
60	0.00075	0.72408	0.47887	0.01058	-0.00583	-0.02725	-0.00699	-0.00016	-0.36244	0.72033	0.00592	-0.00431	-0.01085	0.01455

Table 3 Limit order executions of NYSE-listed IPOs

This table presents the mean and median of the proportion of executed limit orders (LO). Proportions are calculated using the share volume and dollar volume of trades in Panel A and B, respectively, and are given for all limit orders, limit order sells (market buys) and limit order buys (market sells). For the comparison of the pre- and post-decimalization means and medians, we report the t-statistics and the z-statistics based on Wilcoxon signed ranks test. *, **, and *** represent the 10%, 5%, and 1% two-tailed significance level, respectively.

		Pre-decimalization				Post-decimalization			
		Hot (52)	Warm (33)	Cold (29)	All (114)	Hot (58)	Warm (40)	Cold (28)	All (116)
Panel A Share Volume Proportion									
LO Sell	Mean	18.08	18.56	12.93	17.06	10.12***	12.78***	11.62	11.40***
	Median	17.10	17.15	10.53	15.91	9.38***	11.62***	10.30	10.23
LO Buy	Mean	9.41	13.10	16.01	12.09	7.96	10.37	11.02*	9.53***
	Median	8.22	10.82	13.41	9.67	7.83	9.97	10.19	8.85
All LO	Mean	11.68	14.32	12.64	12.69	8.81***	11.36**	10.88	10.19***
	Median	11.27	14.29	10.95	11.76	8.26***	10.72**	10.16	9.26
Panel B Dollar Volume Proportion									
LO Sell	Mean	16.50	19.93	13.94	16.78	11.98**	13.23**	11.81	12.47**
	Median	15.74	18.41	9.33	15.71	10.34**	11.64**	11.66	11.02
LO Buy	Mean	8.03	13.26	17.09	11.97	8.22	10.11*	9.72*	9.24***
	Median	7.53	12.18	14.75	9.46	8.04	10.08*	8.77	8.58
All LO	Mean	10.65	14.67	12.58	12.25	9.78	11.32**	10.16	10.48*
	Median	10.69	15.20	10.01	11.63	8.88	11.08**	9.03	8.99

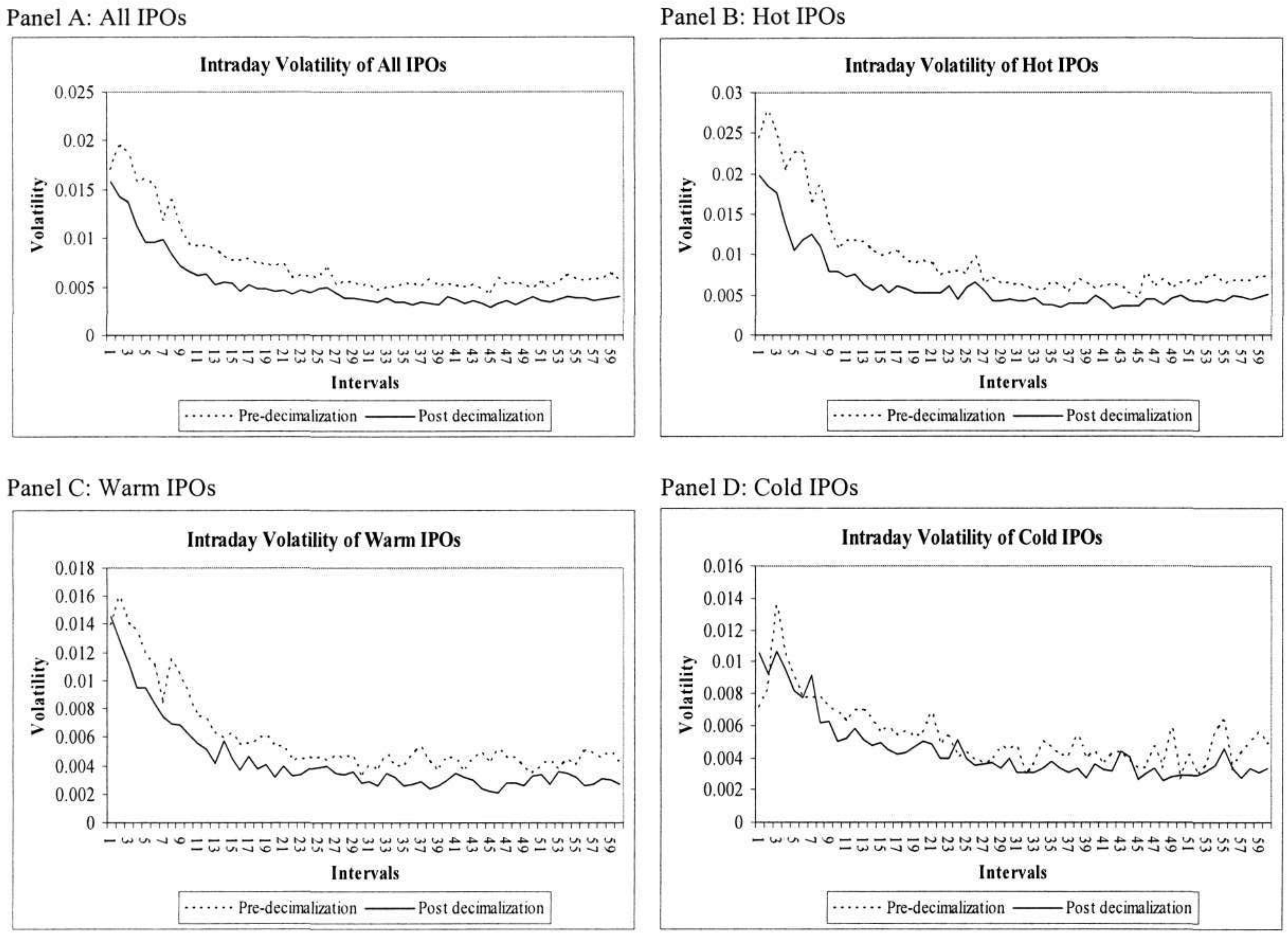
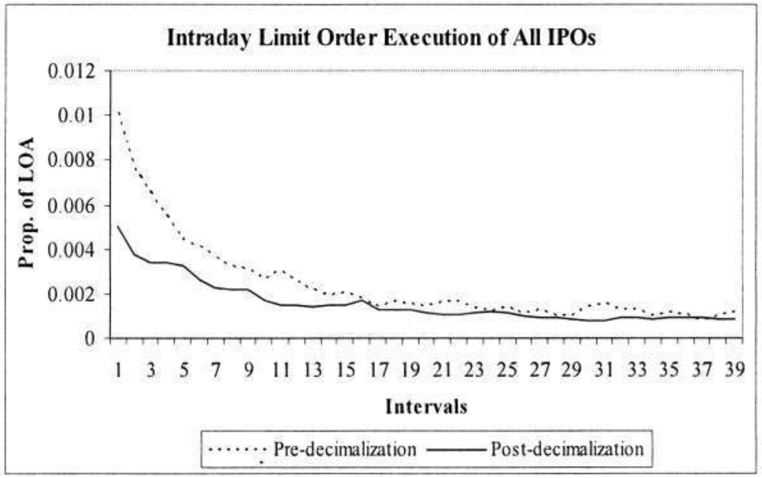
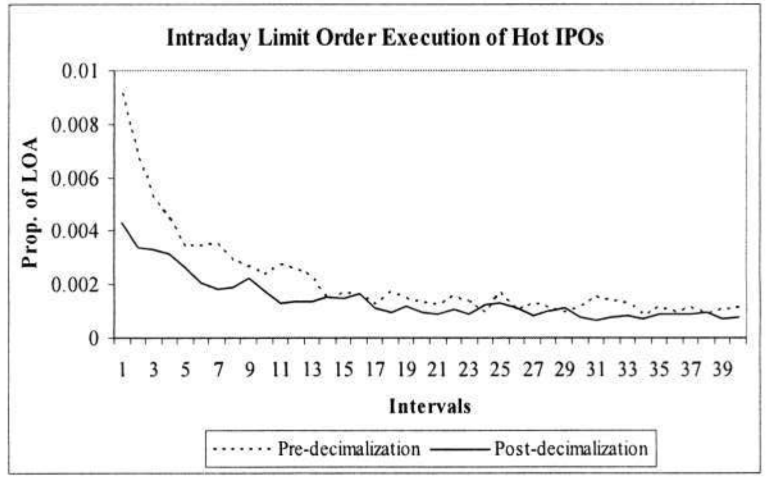


Figure 1. This figure plots the intraday volatility for all, hot, warm, and cold IPOs in Panel A, B, C, and D, respectively. Each interval represents 5-minute.

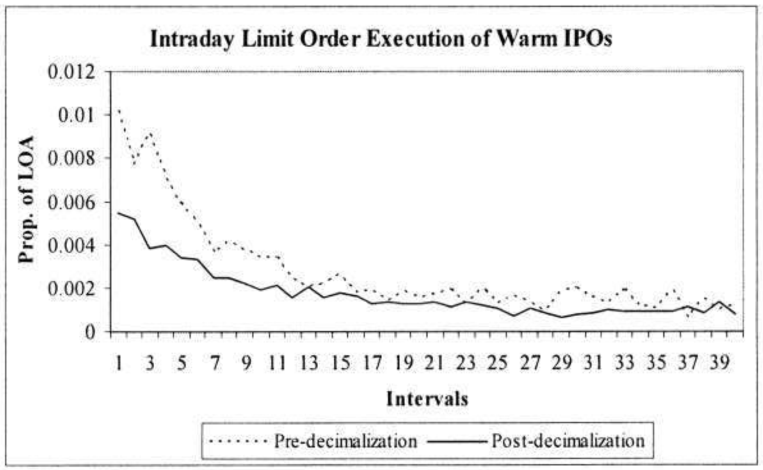
Panel A: All IPOs



Panel B: Hot IPOs



Panel C: Warm IPOs



Panel D: Cold IPOs

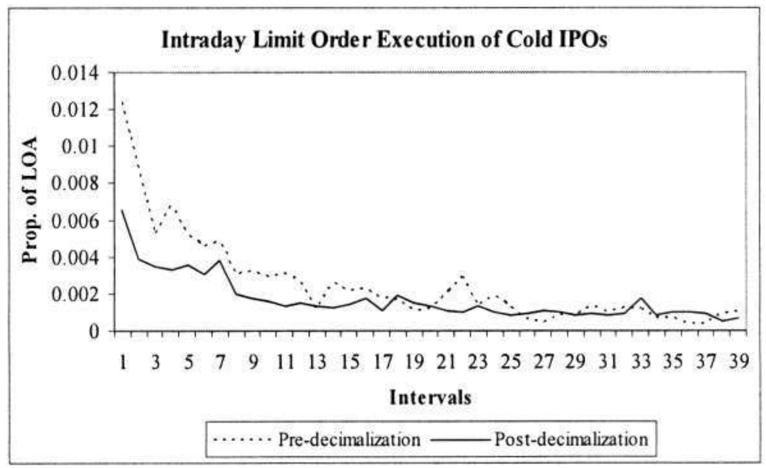


Figure 2. This figure plots the median values of the intraday proportions of limit order executions for all, hot, warm, and cold IPOs in Panel A, B, C, and D, respectively. The proportion is computed based on the volume comparing the number of shares executed as limit orders to the number of shares executed for all orders. Each interval represents 5-minute.

Appendix 1
Sequence of Quotes and Transactions with Limit Order Executions